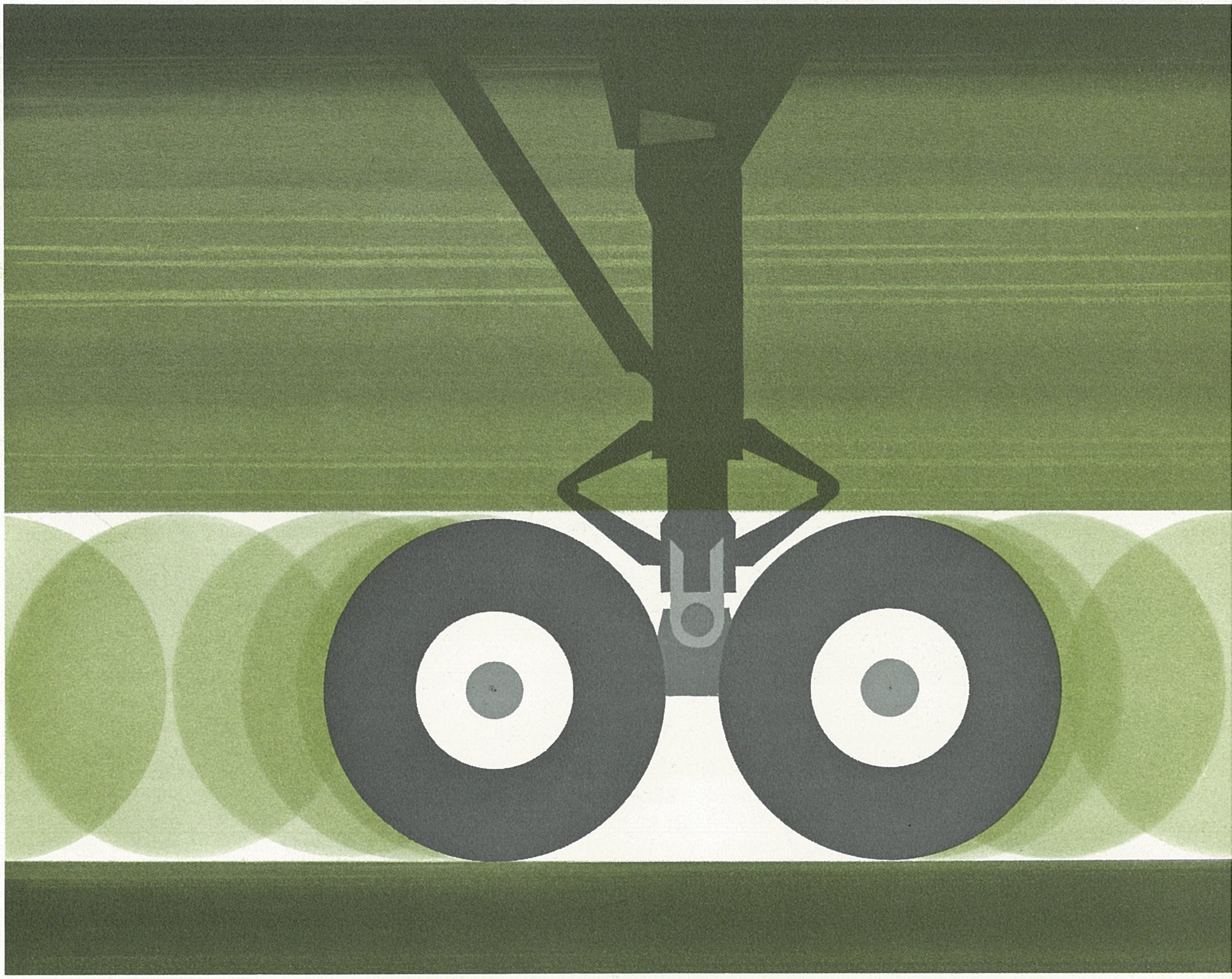
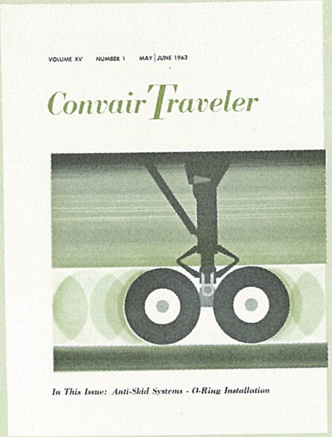
VOLUME XV NUMBER 1 MAY | JUNE 1963

Convair Traveler



In This Issue: Anti-Skid Systems - O-Ring Installation



VOLUME XV NUMBER 1 MAY | JUNE 1963

Convair Traveler

In This Issue: Anti-Skid Systems - O-Ring Installation

OUR COVER

By one of those flashes of inspiration native to genius, Norm Rutherford, artist for this issue, manages to suggest themes of two leading articles — O-rings and braked landing gear. He says he didn't mean to, but he'll be glad to take credit.

Convair Traveler

VOLUME XV NUMBER 1 MAY/JUNE 1963

MANAGER, CUSTOMER SERVICE — O. W. HARPER
CHIEF ENGINEERING SERVICE — L. J. BORDELON
CHIEF, FIELD SERVICE — R. W. SOMMERS
CHIEF, SERVICE PARTS — J. DOIG
CHIEF, TECHNICAL PUBLICATIONS — H. R. KENNEDY
EDITOR — GERTRUDE S. HUNTER

IN THIS ISSUE

PAGE 3
ANTI-SKID SYSTEMS 880/880M/990
H. R. Smith

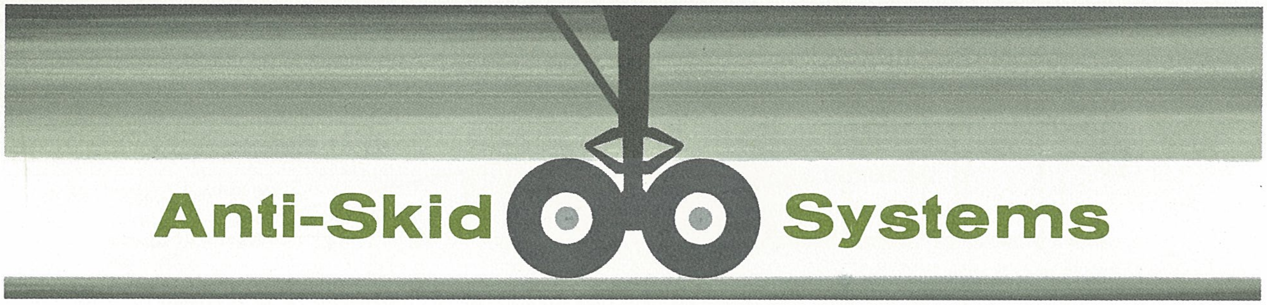
PAGE 10
THE GENTLE ART OF O-RING INSTALLATION
G. S. Hunter

PAGE 13
CARE AND HANDLING OF PASSENGER SEATS 880M/990
R. K. Lawson

A digest of operation and service published monthly by the Technical Publications Section of GD|Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics|Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

COPYRIGHT 1963

GENERAL DYNAMICS | CONVAIR



Anti-Skid Systems

Convair 880/880M/990

Continuing improvement in a rapidly developing field is reflected in the successive stages of advance in Convair jet airliners' braking efficiency.

LARGE AIRCRAFT NEED ANTI-SKID PROTECTION for two reasons — to protect the tires, and to provide more efficient braking. It has long been established that a fully braked rolling wheel stops a vehicle more effectively than does a locked wheel. But, when anti-skid devices were first introduced, the first consideration may have been the more important. Blowouts were expensive, possibly damaging, and sometimes dangerous. They still are; and at jet touchdown speeds, a new tire will blow in a second or two of skidding.

Braking efficiency, however, is far more important to jet transports than mere protection against tire damage. The state of the art has gone a long way beyond just freeing a skidding wheel. Much of the development has been within the last five years. The Convair 880, 880M, and 990 systems reflect successive stages of advance in technology, a progression ending in sophisticated electronic circuitry and high-response valves that provide not only skid protection but near maximum brake efficiency over a wide range of conditions.

The first anti-skid devices were merely warnings, such as foot-thumpers that pulsed when a wheel skidded. They depended on pilot reaction time as well as brake system operating delay. Thumpers were quickly succeeded by comparatively simple mechanical devices that would release brakes automatically. One early type, installed on some Convair-Liners by operators, was inertially actuated. When the wheel stopped turning, a flywheel within the wheel overran to operate a mechanical linkage that closed a valve, cutting off brake hydraulic pressure, and reopened the valve when the wheel accelerated again.

This shortened the anti-skid response time, and it could be coupled to each wheel separately. But rather than preventing a skid, it tended to result in a series of short abrupt skids, with no braking at all between cycles. Braking efficiency depended on the pilot recognizing the skid and relieving some pressure on the brake pedals. The on-off cycling sometimes resulted in excessive stress from landing gear "walking" when the engage-release timing coincided with the gear's natural structural frequency.

Convair 880/880M System

The Convair 880/880M anti-skid system is essentially a refinement of the inertia-actuated, on-off system just described. Skid detection is more sensitive, the valving is electrically actuated and much faster, and the response time is lowered until the wheel actually stops only for an instant.

This type of system is in use in some form in most jet transports today. Other aircraft besides Convair's use some of the same components. The skid detector is still a flywheel clutched to the landing wheel; but a very slight overrun trips an on-off switch that releases brake pressure through a solenoid-operated valve, and wheel acceleration trips another switch that reapplies braking.

Though response time, from skid detection to brake pressure release, is measured in fractions of a second, this system by itself leaves something to be desired. Cycling can still cause excessive structural stress if it continues at certain frequencies, and braking is still lost for too much of the time when maximum pedal force is applied by the pilot. One solution is the pedal-thumper, warning the pilot to let up on the pedals. Convair, however, on its jet transports, has insisted that even in maximum pedal force braking, with the pedals pushed down to the pedal stops, the pilot should have as much braking available as possible.

The Convair 880/880M distinctive feature was the addition of an accumulator in the hydraulic line, up-

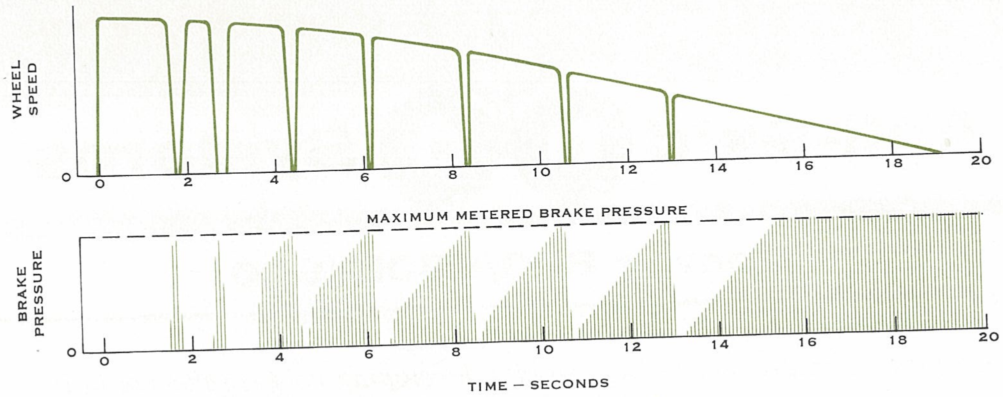


Figure 1. Time history of system operation — 880 anti-skid system.

stream of the pilot-operated main brake metering valve. The accumulator, termed a pressure modulator, is fed through a restrictor during anti-skid cycling, so that pressure down stream of the modulator drops with each successive release of brake pressure, until within a few seconds a relative equilibrium is attained, at which point braking is nearly continuous. Figure 1 is a stylized time history of the operation.

This summary description may convey an over-simplified picture of the 880/880M system, particularly from an electrical viewpoint. Skid detector signals actually go into a control box that houses five relays for each wheel, plus assorted diodes, RC time delay circuits, and additional arming and bypass relays for the main wheels. There is one control box for main wheels and one for the nose wheels. Hydraulic components include four dual control valves for the main wheels, one control valve for the co-rotating nose wheels, and the pressure modulators. The 880 has two modulators, one for the nose wheel and one that governs pressure to all eight main wheels. The 880M has a modulator for the main wheels and an accumulator-restrictor combination for the nose wheels.

The 880M nose wheel brake system differs from that in the 880, in that nose brakes are actuated only when the pedals are almost fully depressed, and hence are used only when maximum braking is demanded.

The main wheel modulator has a solenoid-operated bypass valve to permit the flow volume necessary for the original application of brakes. The control circuitry opens the bypass when skid cycling ceases. The circuitry also protects against landing with brakes on, releases all pressure to a wheel if it locks, reverts the system to normal braking when the brakes are released for a few seconds, and warns the pilot through a panel light when anti-skid protection is lost on any main wheel. The entire system can be deactivated at any time by a flight compartment switch.

By flight test, optimum modulator pressure and restrictor orifice sizes were determined. The 880/880M systems have worked well, on the whole. Deceleration available from brakes alone is about 12 ft/sec/sec.

This is high enough to call for some caution when the full capabilities of the system are called upon, as in a rejected takeoff, for example. To the dynamicist, brake deceleration represents energy to be absorbed, and it is absorbed in heat. After prolonged continuous braking up to the limitations of the anti-skid system, it is well to stay clear of the landing gear until it cools. Figure 2 shows the cooling-off time necessary.

Two limitations of this type of system may be noted. Brake pressure is still almost entirely removed by an anti-skid signal, and for an instant there is no braking until the wheel accelerates and hydraulic fluid is again admitted to the brakes. Landing gear "walking" is unlikely, since each wheel is separately controlled and cycle frequency drops with each cycle; but braking efficiency is lowered by the free-rolling time. The second limitation is that while skid sensing and brake pressure relieving is separate for each wheel, pressure modulation is equal for all main wheels. In a cross-wind, for example, brake pressure would be governed by the upwind wheels, which would cycle more rapidly because of the lighter weight. These limitations have not been very important in ordinary operation, but they are worth noting because they do not apply to the advanced system of the 990.

Convair 990 System

An interesting preface to development of the 990 anti-skid system is the story of Convair's experience with the brake efficiency curves in figure 3. The general shape of the curve is applicable to almost all wheel braking, but the specific values vary. The vertical scale is an index of braking effectiveness, 100% being the maximum coefficient of tire-to-ground friction obtainable by braking. The horizontal scale represents

Brake Limitation Chart - Convair 880M*

EXAMPLE OF USE

Given: Gross weight 150,000 lb.
Airspeed when brakes applied 100 KIAS.
Density altitude 3000 ft.
No wind.

1. Adjust IAS for wind (none required here).
2. Find aircraft gross weight on chart.
3. Move up to 100 KIAS line.
4. Move across to break line at zero altitude.
5. Move parallel to nearest line to density altitude.
6. Move across to right-hand edge of chart to find zone and take action prescribed.

In this example, 30 min of ground cooling or 12½ min of flight cooling required.

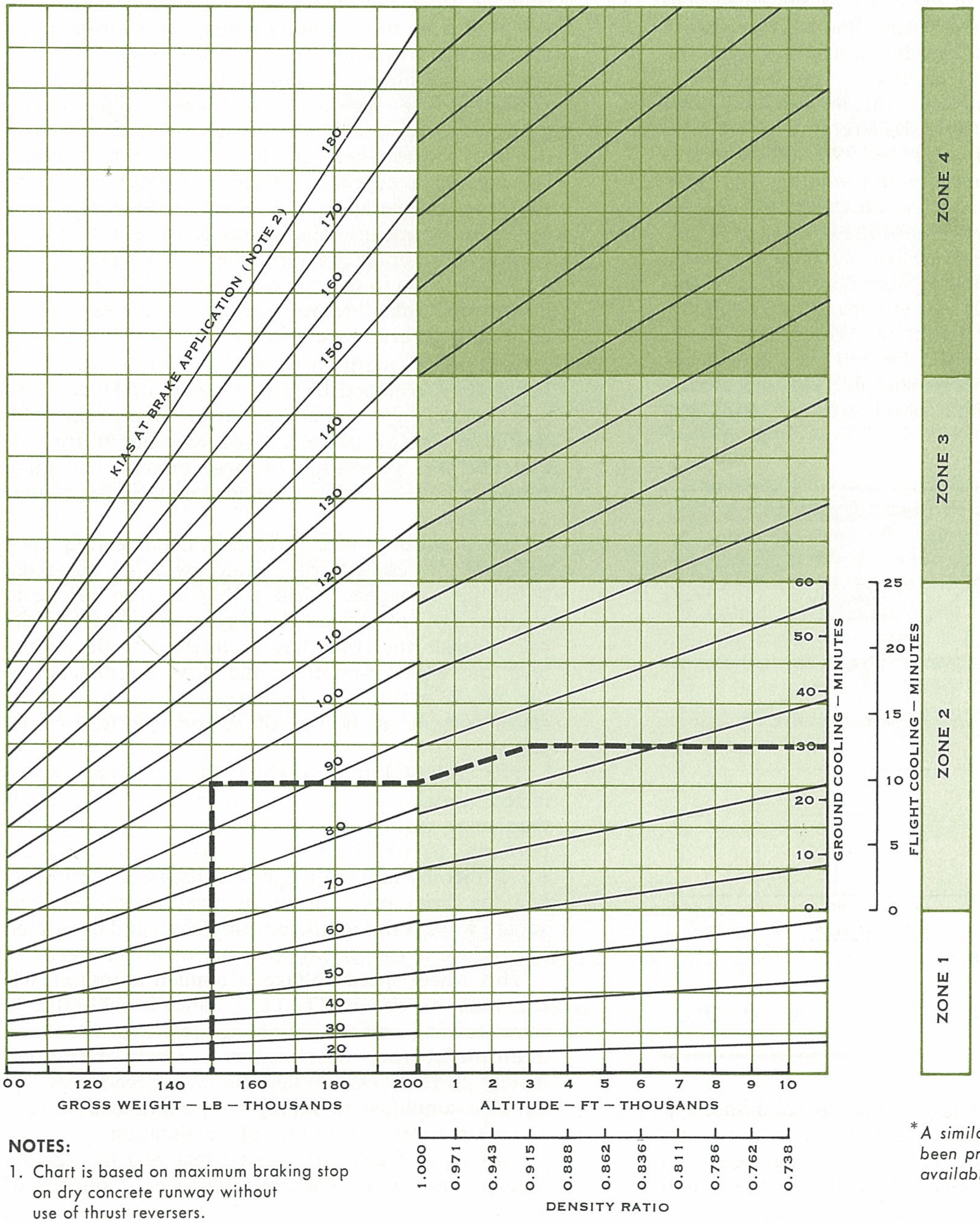


Figure 2.

ZONE 4

1. Clear runway immediately. Request fire fighting equipment. Do not set parking brake.
2. If fire occurs or tires deflate, shut off engines, deplane passengers. Dry chemical extinguishers preferred; do not spray fog or foam on inflated tires or wheels.
3. If no fire, and tires not deflated, taxi to unloading area and deplane passengers. Do not set parking brake.
4. Mandatory tire, wheel, and brake replacement.

ZONE 3

1. Taxi to unloading area, deplane passengers. Do not set parking brake.
2. Do not approach wheels for ½ hour.
3. Delay takeoff 1½ hours or until hand can be held on brake housing.
4. Before takeoff, make complete visual check of brakes with pressure on. Apply brakes fully 5 or 6 times. Check for leaks and wear of brakes and tires.

ZONE 2

If brakes are to be cooled on ground before takeoff, use GROUND COOLING column. If immediate takeoff is to be made, use FLIGHT COOLING column. Gear must be extended for required period for flight cooling.

ZONE 1

No special procedure required, except for repeated stops, as in pilot training. Cool gear thoroughly before anticipated full stop landing.

NOTES:

1. Chart is based on maximum braking stop on dry concrete runway without use of thrust reversers.
2. Subtract headwind, add tailwind to IAS.

**A similar chart for 880 aircraft has been prepared by Goodyear and is available from the Goodyear Co.*

Chart by Bendix West Coast

the lag in wheel speed behind free-rolling speed, 100% representing a locked wheel.

Extensive dynamometer tests indicated that the ordinary aircraft tire seemed to have most effective stopping force when it lagged 25 to 30% behind free-rolling speed (see dotted line on graph). Using electronic sensing and control, with faster-acting hydraulic valves, it was possible to tailor a system to this slip rate. The curve being smoothly rounded, all wheels could theoretically be kept at very close to 100% braking efficiency, merely by making each one lag about 25%. Such a system was created and tried out successfully on the dynamometer.

It didn't work out that way on the airplane. When the 990 test ship took to the runways, equipped with what promised to be the ideal almost-perfect brake control, the wheels alternately skidded and spun up in a highly discouraging fashion.

The 990 was extensively instrumented and more tests were run to investigate the aircraft's own slip-vs-brake-coefficient relationship. A 990 wheel, it was found, develops its best braking when it lags only an average 8% (the solid line on the graph), rather than 25%. The steep portion of the curve, at the left, represents chiefly tire stretch; for maximum braking, the operating area should be kept near the top of this slope. The peak represents the transition point between static and sliding friction. Where the dynamometer curve was rounded, the 990 tire curve peaks sharply and falls almost as sharply. The tire crosses the peak, from maximum braking to full skid, in a tenth of a second.

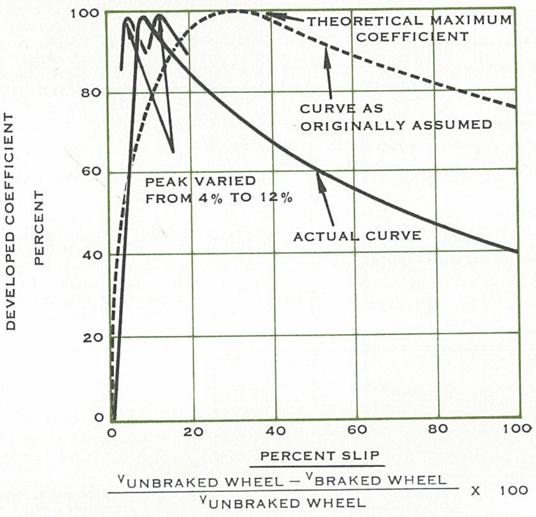


Figure 3. Developed braking coefficient vs. slip.

An additional complexity is that the solid-line, 8% lag peak represents only an average of values found to range between 4 and 12%, depending mostly on speed and runway surface conditions. Were the system matched to a free-rolling pilot wheel speed, for example, at 8% preset slip ratio, under some conditions braking would be inadequate, under others the wheel would be entering a skid. Various dynamic characteristics of a landing gear affect the curve, none of them applicable to a dynamometer.

In this situation, Convair had recourse to one of engineering's recently acquired design tools — the computer. A complete anti-skid system for one wheel was built up in a laboratory, and integrated with an analog computer containing equations describing wheel, strut, and aircraft dynamics. With such a computer model, various changes could be incorporated and their effects predicted.

The system was thoroughly revised, not radically but in detail, both electrically and hydraulically. The flight test-computer design basis turned out to be sounder than the dynamometer basis. The system designed from the computer findings was substantially that which was later put into production, and the flight test results were close to predictions.

Briefly, the system is as follows: The wheel-mounted unit, termed a "transducer" rather than a detector, senses wheel speed only. Anti-skid response is once again keyed to deceleration, rather than to slip ratio; deceleration is detected in the control box by electronic means. The hydraulic valve, rather than cutting off all brake pressure upon a skid signal, lowers it in proportion to the rate of deceleration, and meters flow to the brake lines to keep the brake pressure at a point of high braking efficiency.

The system merits a somewhat more detailed description. Developed by a joint effort of Hydro-Aire and Convair, it is still comparatively new in the field. But it is already being tailored to other transports, and the next generation of large aircraft will quite probably have anti-skid systems closely similar to that on the 990.

The transducer is a variable-reluctance frequency generator. It consists of a stator winding energized to set up a magnetic field within an iron case, and a rotor. The rotor resembles a gear with 36 teeth; the case outside the rotor has 36 internal teeth. As the teeth move past each other, the varying reluctance of the magnetic field sets up sinusoidal variations in the stator current, at the rate of 36 for each turn of the wheel.

The control box into which the transducer signal is fed contains transistor electronic circuitry, rather than relay sequences. The sinusoidal frequency, proportional to wheel speed, is converted to a square wave, thereby making the signal insensitive to imperfections from noise or mechanical tolerances. The square wave is differentiated, amplified, and integrated to produce a voltage proportional to wheel speed.

This wheel speed voltage is applied across an RC rate memory circuit. The capacitance is calibrated to reject sensing any rate of change less than the maximum useful wheel deceleration — a rate of approximately 20 ft/sec/sec. When the rate exceeds this, the signal is amplified to supply to the anti-skid valve a voltage proportional to rate of deceleration.

This type of circuitry can be matched to exacting requirements. With a wheel transducer frequency of more than 600 cps at a 120-knot touchdown speed, deceleration can be sensed almost instantaneously. Instant detection of an impending skid, however, is

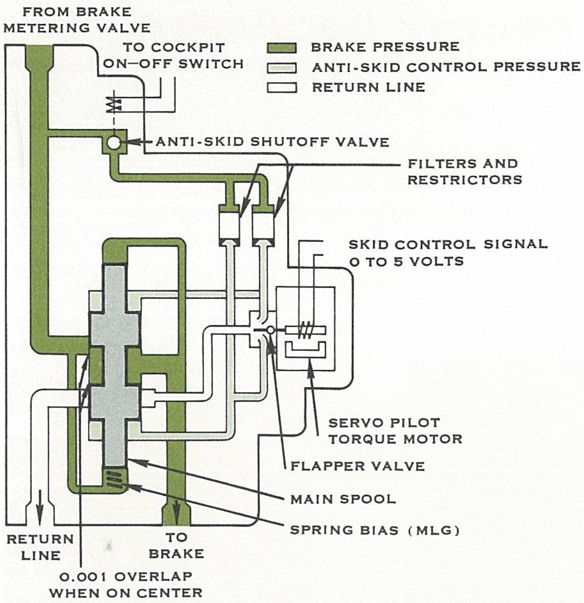


Figure 4. Schematic of MLG anti-skid control valve, with anti-skid energized, normal braking.

only half the requirement; brake system response should also be rapid enough to forestall the tenth-second transition from rolling to skidding, with a corresponding rapidity of recovery. To achieve a response time of this order, the anti-skid valves as well as the control box had to be modified during the Convair 990 test program.

A schematic of the valve appears in figure 4. The main spool of the valve is force-balanced, primarily by hydraulic pressures upstream and downstream of the valve, and secondarily by pressures from the servo pilot valve controlled by the anti-skid signal. With the anti-skid system switch on the flight deck overhead panel in the OFF position, the servo pilot valve is isolated from the hydraulic circuit. The main gear valve spools are spring-loaded toward the valve-open position, to allow brake application directly from the brake metering valve.

The nose landing gear valve differs slightly, in that hydraulic power is entirely shut off when the anti-skid switch is in the OFF position. Also, the spool is spring-loaded in the other direction, towards brakes-off position.

In both valves, the anti-skid switch in ON position opens a solenoid valve, allowing hydraulic fluid flow through restrictors to each side of a flapper-nozzle type unit in the servo pilot valve. With no signal from the anti-skid control box, pressures on the main spool are equal and the pressure metered by the pilot-controlled brake metering valve is permitted to pass through the anti-skid valve undiminished. A skid signal moves the flapper to close off flow through one nozzle, thereby raising pressure in that side to move the spool downward (see figure 3) and open the brake line to return. Since the flapper valve is a torque motor, pressure differential in the servo lines, and the consequent displacement of the spool, are proportional to the strength of the signal.

Brake pressure does not, however, fall to zero. When it is reduced a certain amount, the differential pressure in the servo hydraulic circuit is balanced by a differential in pressures upstream and downstream of the valve, and the valve spool centers. As soon as the skid signal disappears, which is at the point where wheel deceleration drops below the threshold of the rate memory circuit, servo hydraulic pressures equalize and the spool is again driven upward to reapply brake pressure.

Although this is, strictly speaking, still an "on-off" cycling of hydraulic pressure, the effect, for practical purposes, is a constant metering, rather than a stop-start cycling. Valve response is fast and extremely sensitive. When brake pressure is stable, with the spool on center, valve overlap is only 0.001 inch. Hard braking causes the servo flapper and spool to move constantly, relieving pressure one instant and reapplying it the next. The resulting sequence of brake application is shown graphically in figure 5; at no time does

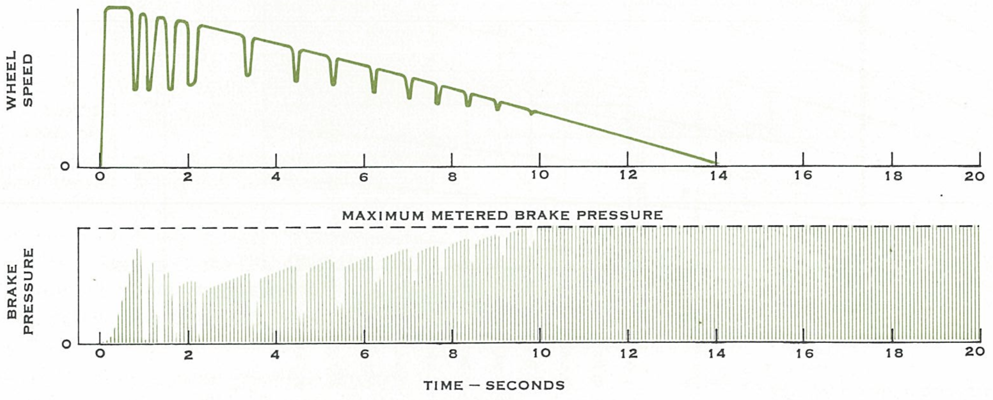


Figure 5. Time history of system operation — 990 anti-skid system.

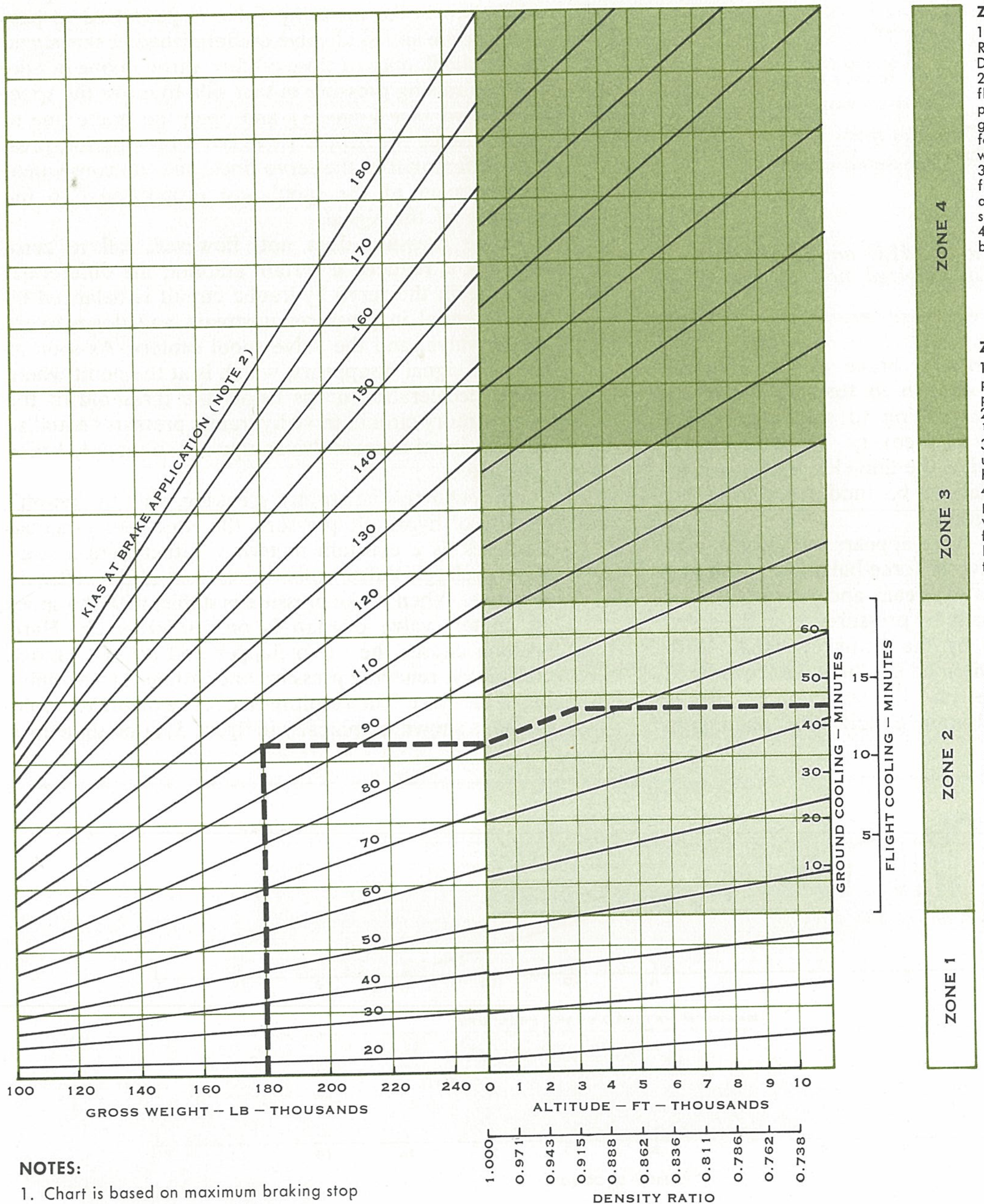
Brake Limitation Chart - Convair 990/990A

EXAMPLE OF USE

Given: Gross weight 180,000 lb.
Airspeed when brakes applied 120 KIAS.
Density ratio 0.915.
Headwind 10 knots.

1. Adjust IAS for wind (110 KIAS).
2. Find aircraft gross weight on chart.
3. Move up to 110 KIAS line.
4. Move across to break line at zero altitude.
5. Move parallel to nearest line to density altitude.
6. Move across to right-hand edge of chart to find zone, and take action prescribed.

In this example, 45 min ground cooling or 13 min flight cooling required.



ZONE 4

1. Clear runway immediately. Request fire fighting equipment. Do not set parking brake.
2. If fire occurs or tires deflate, shut off engines, deplane passengers. Dry chemical extinguishers preferred; do not spray fog or foam on inflated tires or wheels.
3. If no fire, and tires not deflated, taxi to unloading area and deplane passengers. Do not set parking brake.
4. Mandatory tire, wheel, and brake replacement.

ZONE 3

1. Taxi to unloading area, deplane passengers. Do not set parking brake.
2. Do not approach wheels for ½ hour.
3. Delay takeoff 1½ hours or until hand can be held on brake housing.
4. Before takeoff, make complete visual check of brakes with pressure on. Apply brakes fully 5 or 6 times. Check for leaks and wear of brakes and tires.

ZONE 2

If brakes are to be cooled on ground before takeoff, use GROUND COOLING column. If immediate takeoff is to be made, use FLIGHT COOLING column. Gear must be extended for required period for flight cooling.

ZONE 1

No special procedure required, except for repeated stops, as in pilot training. Cool gear thoroughly before anticipated full stop landing.

NOTES:

1. Chart is based on maximum braking stop on dry concrete runway without use of thrust reversers.
2. Subtract headwind, add tailwind to IAS.

Figure 6.

the wheel slow to an actual stop, and braking can be maintained at near maximum effectiveness almost continuously.

The control box circuit provides for a "hard-over" signal for a locked wheel. Valve response is fast enough, and hydraulic system design efficient enough, to drop brake pressure from skid pressure to zero in 0.030 second. Because anti-skid response is so swift, and potentially so instantly effective, some damping of valve action is needed for ordinary braking. This is handled in the control box by a feedback circuit, somewhat analagous to an audio circuit's automatic volume control, termed "pressure bias modulation," wherein the skid signal is attenuated as a function of its intensity.

The 990 consistently achieves 1/2-g deceleration, a deceleration rate of 15 to 16 ft/sec/sec, regardless of tire condition. Braking coefficient is approximately .39, which is more than 80% of the theoretical maximum.

On wet runways, efficiency of the basic system proved to be about 50% of the theoretical maximum. This is better than current systems where a skid signal dumps all brake pressure. But Convair was not satisfied; it is under adverse conditions that effective braking is most needed. Further investigation shows that the loss in effectiveness was due to pressure surging at low hydraulic pressures, which meant, in effect, that where light brake pressure would cause a skid, anti-skid response was still too drastic.

The solution, again determined by computer analysis and evaluation, was a pair of comparatively simple changes, one mechanical and the other electronic. A detent was added in the pedal linkage, requiring extra pedal pressure for heavy braking on dry runways; this helps the pilot to keep brake pressure low. In the control box, the pressure modulation was increased, to further attenuate the anti-skid response under low-pressure conditions. In some aircraft, a pressure regulator was added in the nose wheel brake system to reduce metered pressure for wet runway conditions only. Full metered pressure is still available if required.

Flight test proved that the system could attain an efficiency relatively as high on wet runways as on dry. A series of additional test runs made at Seattle last fall (during the near-typhoon that rained out the West Coast World Series games) demonstrated results even better than 80% of theoretical maximum.

All the safeguards present in the previous systems against locked wheels or component malfunction, and all provisions for warning and emergency operation, are included in the 990 brake system. The efficiency of the braking puts a load even greater than the 880's on tires, wheels, and the brakes themselves. Figure 6 is a chart showing times required for cooling after a heavy braking run.

An average 80% of maximum possible braking is a very high efficiency quotient. What it means in terms of flight safety, and of operational advantage in lower field length requirements, is apparent from the graphs in figures 7, 8, and 9.

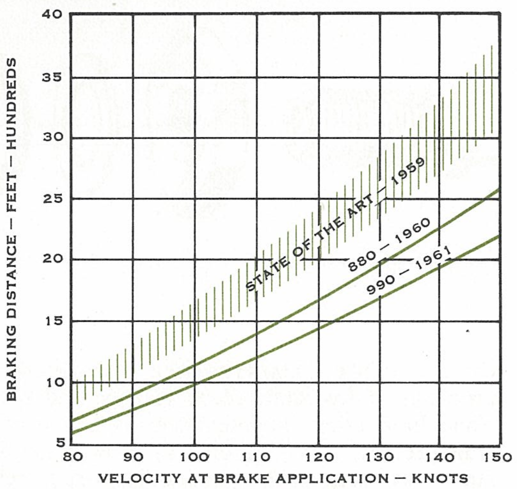


Figure 7. Braking distance — dry runway.

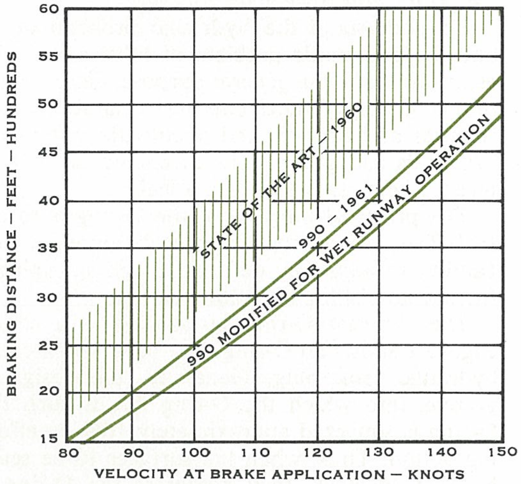


Figure 8. Braking distance — wet runway.

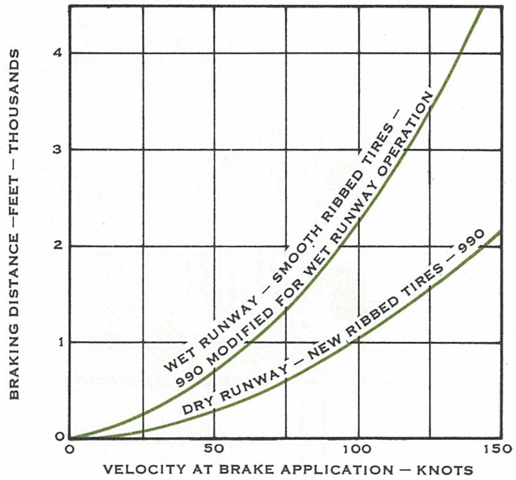
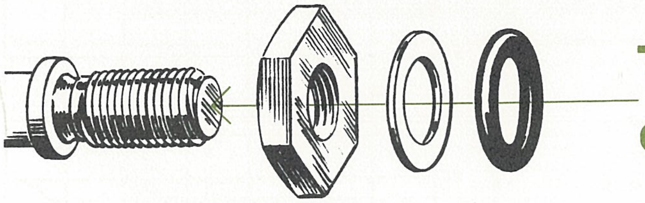


Figure 9. Braking (990) on wet and dry runways.



The Gentle Art Of O-Ring Installation

O-RINGS FROM A MAINTENANCE STANDPOINT involve problems of hydraulic gland leakage and pneumatic gland lubrication. Maintenance inspection of O-ring seals presents two questions: 1) How many drops of fluid must seep past a hydraulic O-ring before an objectionable leak is indicated? 2) How much air must seep past a pneumatic O-ring before there is an indication of a damaged O-ring or of a need for lubrication to reduce wear by friction?

To understand the hydraulic problem of leakage and the pneumatic problem of lubrication, it is necessary to study the general purpose, design, and function of O-rings, and to consider separately the special features of hydraulic and pneumatic system O-rings. With this background, the mechanic can tell the difference between a seep and a leak.

The principal purpose of the O-ring is to act as a seal. The O-ring depends primarily upon its resiliency (ability to adjust by deforming and springing back) for accomplishing its sealing action.

The simplest O-ring installation is a static seal. Figure 1 shows an O-ring on a bolt, which could be a hydraulic tank plug. Generally, the design of the groove, into which the O-ring fits, is such that the O-ring is squeezed approximately 10% to effect sealing action. Thus, when the surfaces to be sealed are brought together, they compress the O-ring and it serves as a gasket. The resiliency of the O-ring also allows it to stretch out under pressure so that the ring contacts the outer face of its confining groove to provide additional sealing action. It is important to note that the under surface of the bolt head fits tightly on the boss. Any crack will allow the O-ring to extrude.

In the static type and, for that matter, in all O-ring sealing installations, it is important that just the proper size O-ring be used, that the O-ring and the parts it contacts be smooth and free of irregularities, and that all of the parts be clean. Slight imperfections and/or contamination can be instrumental in causing leakage. An imperfection or a bit of foreign matter can create an opening path (past the O-ring) through which fluid can flow.

The O-ring must also be of a material that is compatible with the particular fluid in the system. If the wrong material is used, the O-ring may swell excessively and deteriorate.

A fresh O-ring when installed may normally swell as much as 10% when exposed to the fluid and working operation. Allowance is made for this in the design of the O-ring groove. Excessive swelling, however, indicates that the O-ring and fluid may not be compatible. In components that must remain at very low friction values to properly function, excessive swelling of O-ring seals may increase friction many times beyond the maximum allowable value.

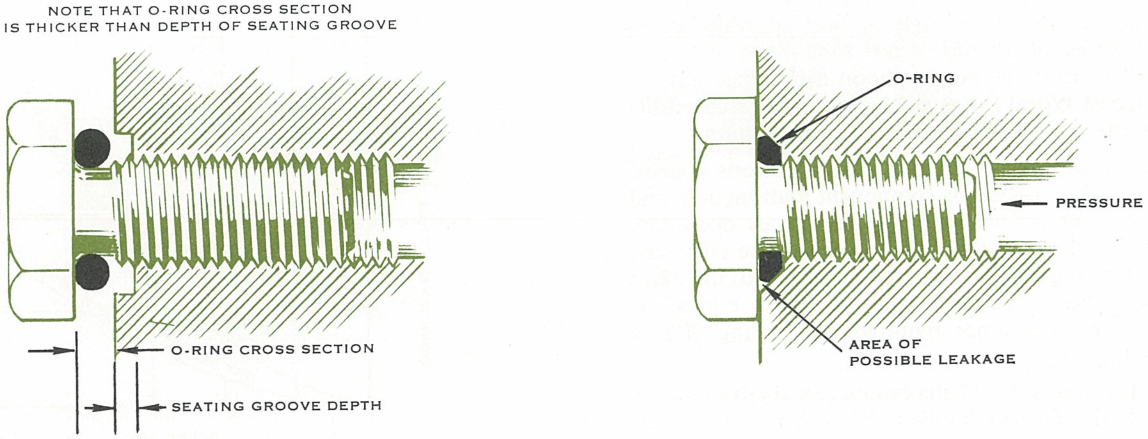


Figure 1. Static seal — no moving parts.

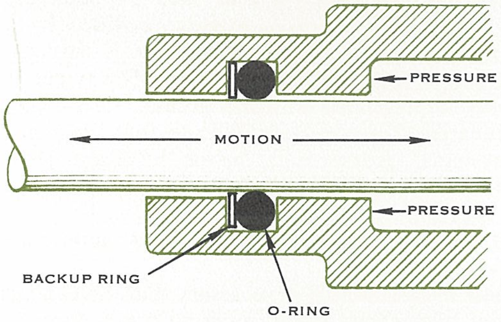


Figure 2. Running seal with single backup ring.

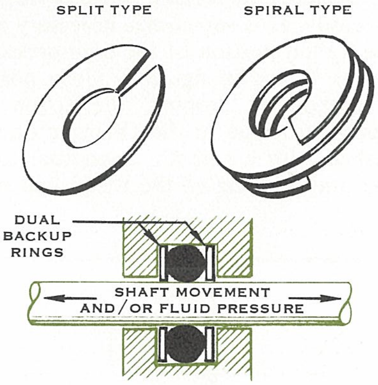


Figure 3. Running seal with dual backup rings.

A proper O-ring installation generally results in a diametral squeeze of approximately 10% of the O-ring cross section. The volume of the O-ring is also slightly less than the volume of the groove. The initial squeezing is to facilitate a proper seal; the slight "left-over" area in the groove is to accommodate slight normal swelling and to permit a sliding, rolling, and kneading action of the O-ring under pressure and movement. The rolling aids in working fluid under the O-ring, and thus keeps it lubricated.

A simple O-ring installation involving moving parts (running seal), is shown in figure 2. This is a common type of application used where the pressures to be restrained run from zero to about 1500 psi.

Where movement is involved, the installation specification generally defines an amount of leakage that is permissible. A slightly moist surface is an indication that the system fluid is lubricating the O-ring as necessary. The specification will generally stipulate that there shall be no leakage when the assembly is static, and will allow a few drops of fluid to form per minute during operation. Permissible leakage will vary, depending on whether the seal encounters intermittent or continuous motion.

More than the specified maximum number of drops per minute, however, indicates 1) a fault in the installation, 2) nicked or scratched sealing surfaces, 3) foreign particle contamination, or 4) worn or damaged O-rings.

Where the higher pressures are being sealed off with O-rings (operating pressures generally above 1500 psi), backup rings may be used with O-rings. Two types of backup rings are shown in figure 3 — the "split washer" and "spiral" types.

Backup rings provide a firm surface against which the O-ring can press to avoid being extruded, under high pressures, into the clearance between the surfaces being sealed. If these backup rings were not provided, the high pressures could "squeeze out," or extrude, some of the O-ring into the clearance space. Any movement between the surfaces, when the O-ring is thus deformed, would result in a high rate of O-ring wear, and the ability of the O-ring to provide an effective seal is soon lost. (See figure 4.)

With O-rings properly fitted, the breakout force (effort needed to start movement) is not generally large. Breakout friction or force is higher than running friction, and is the largest factor that must be considered in the design of O-ring seals.

To prevent grabbing or seizing of smooth surfaces under high pressure, slipper rings are provided. These, in cross-section, may be U-shaped, L-shaped, or plain bands, and they are usually made of Teflon. (See figures 5 and 6.)

The Teflon material has a very low coefficient of friction, which means that it will start out with a low breakout force and run with relatively no friction under load, even in the absence of lubrication. The free-sliding slipper rings thus adapt the sealing resilience of the O-rings to the higher working pressures.

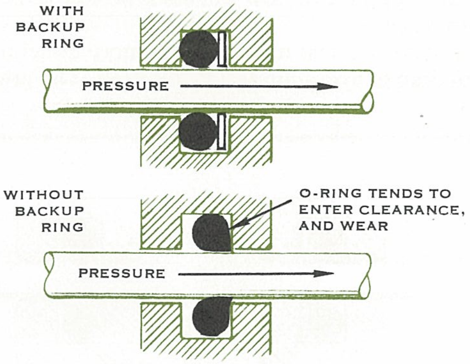


Figure 4. Installation of backup rings.

A different technique is required for installing slipper rings because the Teflon material does not "deform" as easily. It is sometimes necessary to "double back" the Teflon portion of the high-pressure O-ring assembly, as shown in figure 5. Once positioned, it requires working or "ironing" the Teflon ring back into its original shape in the O-ring groove. This is accomplished with a smooth nylon tool to preclude scratching and marring of the metal and the slipper rings.

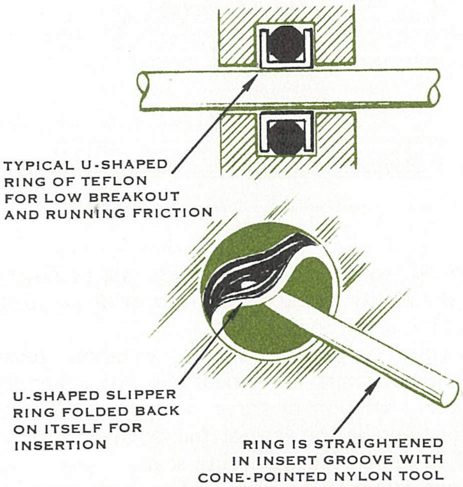

TYPICAL U-SHAPED RING OF TEFLON FOR LOW BREAKOUT AND RUNNING FRICTION
U-SHAPED SLIPPER RING FOLDED BACK ON ITSELF FOR INSERTION
RING IS STRAIGHTENED IN INSERT GROOVE WITH CONE-POINTED NYLON TOOL

Figure 5. Installation of U-shaped seal.

Particular care must be taken with *all* O-ring installations to avoid damaging the rings. All parts with which the O-ring is likely to come in contact during assembly should be smooth to prevent cutting or shearing of any part of the O-ring. The tools used to aid in positioning the O-rings should be made of nylon or similar material so that the ring and its mating groove are in no way scratched or nicked. This practically rules out the use of metallic tools. Lubricating the O-ring with the system fluid or with a grease compatible with the system will assist in sliding the O-rings into place.

Pneumatic seal lubrication is more difficult to control than is hydraulic seal lubrication. The pressurized air that enters the pneumatic seal from the system does not lubricate; in fact, it dries out the seal and any lubricant that may be on the packing.

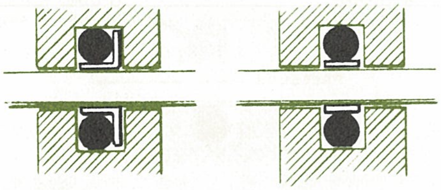


Figure 6. L-shaped seal on left; plain on right.

To maintain an effective seal with a pneumatic system O-ring, lubrication is usually provided by a felt wiper. During overhaul, this wiper is serviced with MIL-L-4343A lubricating grease. The wiper is thoroughly impregnated with this grease, not superficially smeared. Tests to date indicate that, in pneumatic systems, grease is a better lubricant than hydraulic fluid, both in dynamic and static seals. Service experience indicates that a unit can be operated 50,000 continuous cycles without additional lubrication.

In some installations it is necessary that the O-rings be passed over sharp edges, such as screw threads. In such instances, it has been found practical to cover these raw edges tightly with a thin plastic tape, then to lubricate the O-ring, and work it into position, after which the tape is removed. (See figure 7.)

O-rings in-service undergo a slight swelling and softening and may be subjected to wear that is not always apparent to the eye; these O-rings are prone to inadvertent damage on reinstallation. It is recommended, therefore, that only new rings be used upon reassembly of a unit. This can do much to preclude and eliminate difficulties.

In summary — proper O-ring maintenance necessitates periodic inspection and keen observance. The line mechanic must determine these things:

Is the dripping fluid hazardous (damaging another component) or creating a fire danger?

Is the drip rate excessive?

Has there been any increase in the rate of drip since the last inspection? (Since an increase may indicate the beginning of trouble, the component should be carefully checked at frequent intervals.)

Is the drip rate normal for this type of installation?

Is any air escaping from the pneumatic system? If so, is the hourly leakage rate high enough to require a closer check on all seals?

If the line mechanic understands the purpose of the O-ring and if he realizes that it is not a perfect seal, he will have little trouble making a practical appraisal of how many drops of fluid must leak past a hydraulic seal before the seep becomes an objectionable leak — and he will also know how important it is to replace pneumatic system components that have dry O-rings.

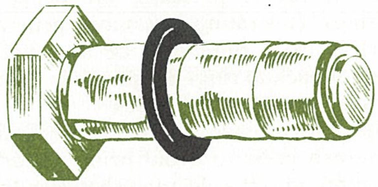
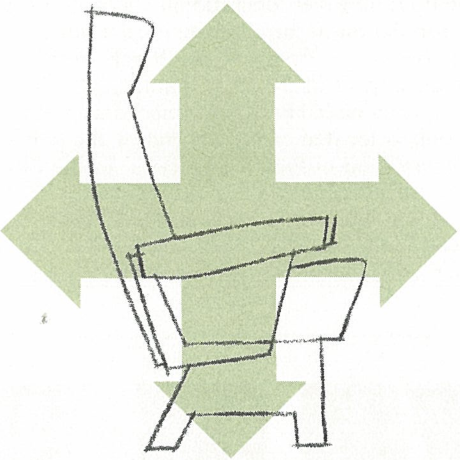


Figure 7. Tape protects O-ring during installation.

Care And Handling Of Passenger Seats



Convair 880M/990

All operations involving seat installation, removal, movement, and adjustment should be performed only by trained personnel

PASSENGER SEATS on Convair 880M/990 airliners are equipped with special attach fittings that engage tracks which are installed in the cabin floor and in the sides of the interior cabin structure. The tracks permit fore and aft movement of the seats to facilitate high or low density seating arrangements.

The seat tracks are actually rails to which the seats attach. They form an integral part of the airplane structure, affording a secure attach point to withstand the forces imposed by airplane maneuvers, hard landings, sudden acceleration, or abrupt stops.

The floor tracks are machined from 7075-T6 aluminum alloy extrusions; they are hard-anodized per AMS2468, and chemical-film-treated per MIL-C-5541, for maximum structural integrity and for resistance to abrasive and corrosive action. The side tracks, like the floor tracks, are machined from 7075-T6 aluminum alloy extrusions, and receive the same chemical-film treatment. Both floor and side seat tracks have indexing detents to assure accurate seating alignment and to permit fore and aft adjustment in one-inch increments.

The inboard seat of each two- or three-seat section is attached to the floor track by means of fore and aft fittings. The fittings are essentially devices that engage the track rail section to prevent vertical or lateral movement of the seat. The aft fitting contains a spring-loaded indexing pin which engages a detent in the track rail to prevent fore and aft movement of the seat.

The side seat tracks, to which the sides of the outboard seats attach, provide both longitudinal and lateral stability to each two- or three-seat section. The side seat tracks are "T" slotted longitudinally to receive the fore and aft seat fittings. Here, the aft fitting also contains a spring-loaded indexing pin which engages a hole in the track rail section.

Duro vinyl covers are provided for both floor and side seat tracks, to protect the areas between the seat attach fittings. The covers are designed in lengths to suit a wide variety of seating arrangements. The covers snap into place by engaging the rail section in the floor tracks, and the "T" slot in the side tracks.

Care should be exercised when handling the passenger seats in order to prevent damage to the seat fabrics, attach fittings, and adjustment mechanisms. The fabrication of a cart that would accommodate a large number of seats could be readily utilized for both storage and transportation purposes when seats are removed from the airplane. Such a cart should have fittings or tracks similar to those in the airplane to afford adequate support for the seats. The ideal arrangement would be to install spare airplane seat tracks in the cart in the same configuration as that in the airplane installation.

Seat Installation

New passenger seats should be stored in the shipping cartons until the time of installation. Then, seats should be arranged in order of installation by dash numbers and color code. If both airplane entrances are to be used, seats should be installed in the center of the airplane first in all-coach or all first-class configuration. In combination coach and first-class seating configurations, the aft seats in the first-class compartment and the forward seats in the coach compartment should be installed first. Protective covers should remain on seats during installation.

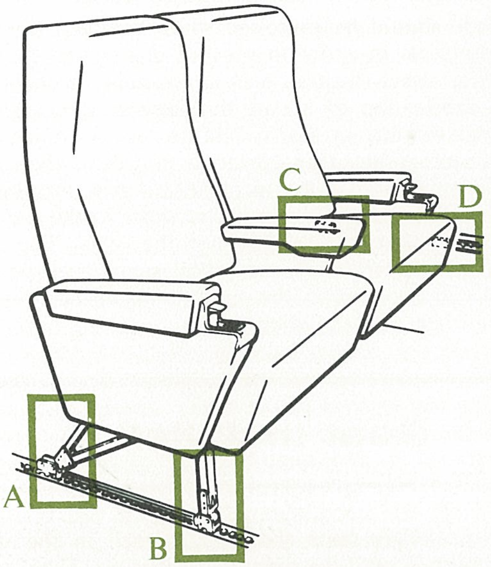
All operations involving seat installation, removal, movement, and adjustment should be performed only by trained personnel. Before each seat section is positioned in the airplane, care should be taken to make sure that the indexing pins for both the floor and side seat attachment fittings are retracted, as shipped. The ring in the side seat fitting should be in the forward and aft detent slots on the sides of the fitting housing. The arrow on the floor seat fitting should be pointed approximately 22 degrees forward of vertical. The slotted anti-rattle adjustment screw (located in each side seat forward fitting and in each floor seat forward fitting) should be turned counterclockwise to the maximum clearance position.

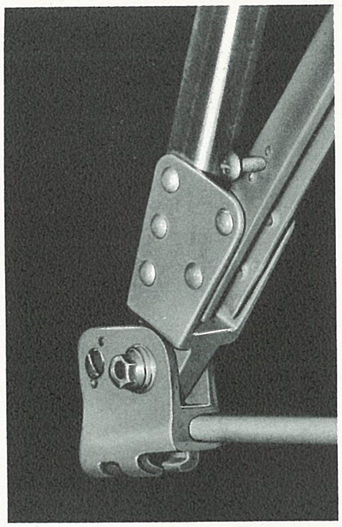
The seat may then be positioned in the tracks so that the side attach fittings engage the "T" slot in the side seat track, and the floor attach fittings engage the rail of the floor track. The indexing pin in the aft side fitting is released by rotating the ring out of the detent slots, and allowing the pin to engage the indexing hole in the side track rail. (Some seats have a handle instead of a ring.) The indexing pin is locked in the aft floor attach fitting by pushing the lock pin in with a screwdriver and rotating the pin clockwise until the red arrow on the lock pin aligns with the red dot on the fitting. When the lock pin is released, the lock pin must spring out to lock the indexing pin in place. The anti-rattle adjustment screw on the seat-to-floor track forward fitting is turned clockwise until all looseness is eliminated.

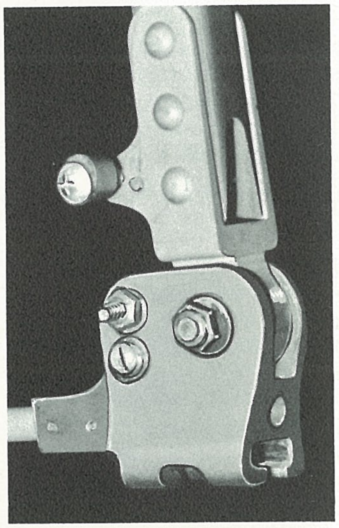
Seat Adjustment

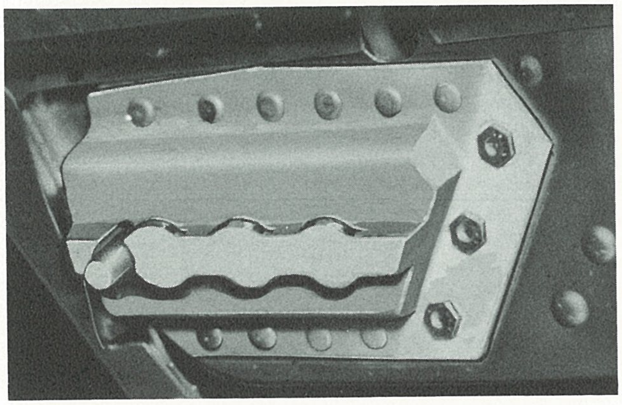
Several adjustments are provided on each passenger seat. These adjustments are set at the vendor's facility and readjustment may not be required following seat installation; however, operational checkout of the seat after installation in the airplane is advisable.

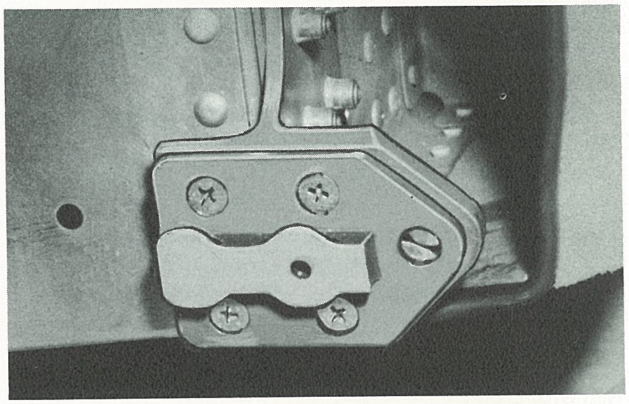
Seat backs are designed to "break over" forward under an impact of 30 to 35 pounds. On those seats with a spring-loaded breakover mechanism, the adjustment bolt is located at the aft end of the seat base at the inboard and outboard arm rests. In the three-seat section, adjustment for the center seat is at the aft base of the inboard center armrest. With armrests removed, adjustment is accomplished by turning the retainer bolt for the breakover fitting spring clock-




A. *Seat-to-floor track aft fitting.*


B. *Seat-to-floor forward fitting.*


C. *Seat-to-side track aft fitting.*


D. *Seat-to-side track forward fitting.*

wise to increase — counterclockwise to decrease — spring tension. After adjustment, it is advisable to operate the seat breakover to remove burrs or roughness from the contacting parts so as to obtain smooth operation. Excessive operation can cause loss of adjustment.

Adjustment for the friction type breakover mechanism is at a bolt accessible through a slot in the seat back torque arm just above the seat back hinge point. Adjustment is made by means of a spring scale attached to a rope around the seat back. Scale should read 30-35 pounds when seat back is moved forward. The bolt is tightened to increase force — loosened to decrease force — to move the seat back forward.

The control lever for the hydraulically-actuated recline mechanism (mechanically-actuated on some airplanes) is located in the forward end of the seat armrest. Control cable tension is adjusted by turning the screw (located under the control lever) counterclockwise to tighten — clockwise to loosen. Properly adjusted, the seat back returns to the upright position when the lock is released and pressure (load) is removed from the seat back.

Lubricant is applied by the vendor and no further lubrication is required.

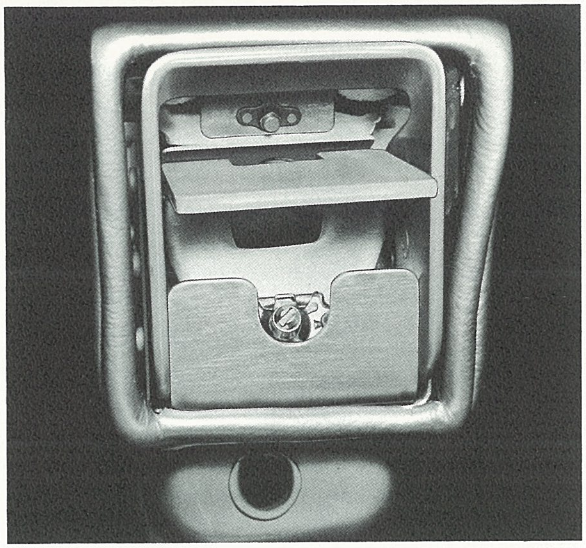
Relocating Seats

When seats are to be moved to accommodate different seating arrangements, the seats can be moved in the track rails for distances up to two feet. If it becomes necessary to move the seat a greater distance, it is recommended that the seat be lifted from the track rails and carried to the desired position using the seat support frame for handling. When sliding the seat in the track rails, it is advisable for one person to pull the seat along the rails. Pushing, or assistance by another person, may cock the seat fittings sufficiently to cause binding, and force them out of station plane.

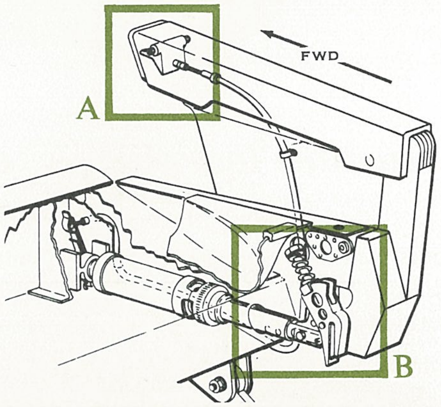
Even though Duro-Vinyl covers are installed to protect the tracks from spilled liquids and other contaminants, seat tracks should be inspected at regular intervals for moisture and other foreign matter. In the event corrosion is present, the following procedures are recommended:

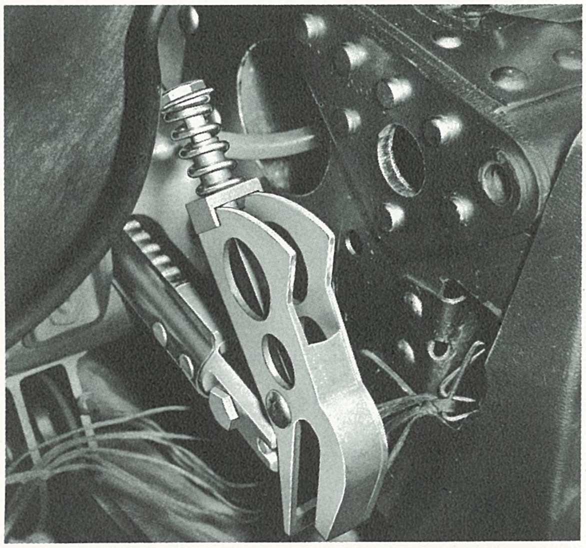
1. Remove oil or grease with naphtha solvent.
2. Sand corroded area with 320 grit aluminum oxide paper.
3. Vacuum area to remove sanding residue.
4. Clean reworked area with solvent.
5. Refinish area with Alodine 1000, using a clean cheesecloth.

MIL-C-5541 is the specification for Alodine chemical conversion coating. Because it contains chromic acid, skin contact should be avoided. Care should be taken to protect floor covering adjacent to the repair area to avoid staining fabrics and materials. The solution is flammable; cleaning cloths should be disposed of immediately. Alodine 1000 may be obtained from Amchem Products Inc., Ambler, Penna.



A. *Seat back recline lever accessible through fwd face of seat arm.*





B. *Seat back breakover mechanism.*

6 32

GENERAL DYNAMICS | CONVAIR TECHBOOK

PROGRAMMED INSTRUCTION

Instant learning . . . through Programmed Instruction

A proven capability for technical and industrial training with programmed instruction is offered by General Dynamics | Convair.

Programmed instruction is training material . . .

- Presented in small steps
- Carefully sequenced to give student exactly what he needs
- Requiring constant student participation
- With feedback that keeps student informed as to his progress
- With self-pacing features to permit learning at student's own rate

This new training concept at General Dynamics| Convair has been successfully used in the training of employees on Value Control and Quality Assurance.

As a result of our in-house experience we now offer instruction for technical and industrial training. Courses offered and those under development include:

- KIFIS (Kollsman Integrated Flight Instrument System)
- Value Control/Value Engineering
- Aircraft & Missile Operational and Maintenance Subjects
- Flight Safety
- Quality Assurance

Programmed instruction "works" — It has been proved that more instruction of better quality can be given to more people with uniform results in less time and at reduced cost.

Let us know your current and future training needs and we will develop a customized Programmed Instruction course to meet your particular requirements.

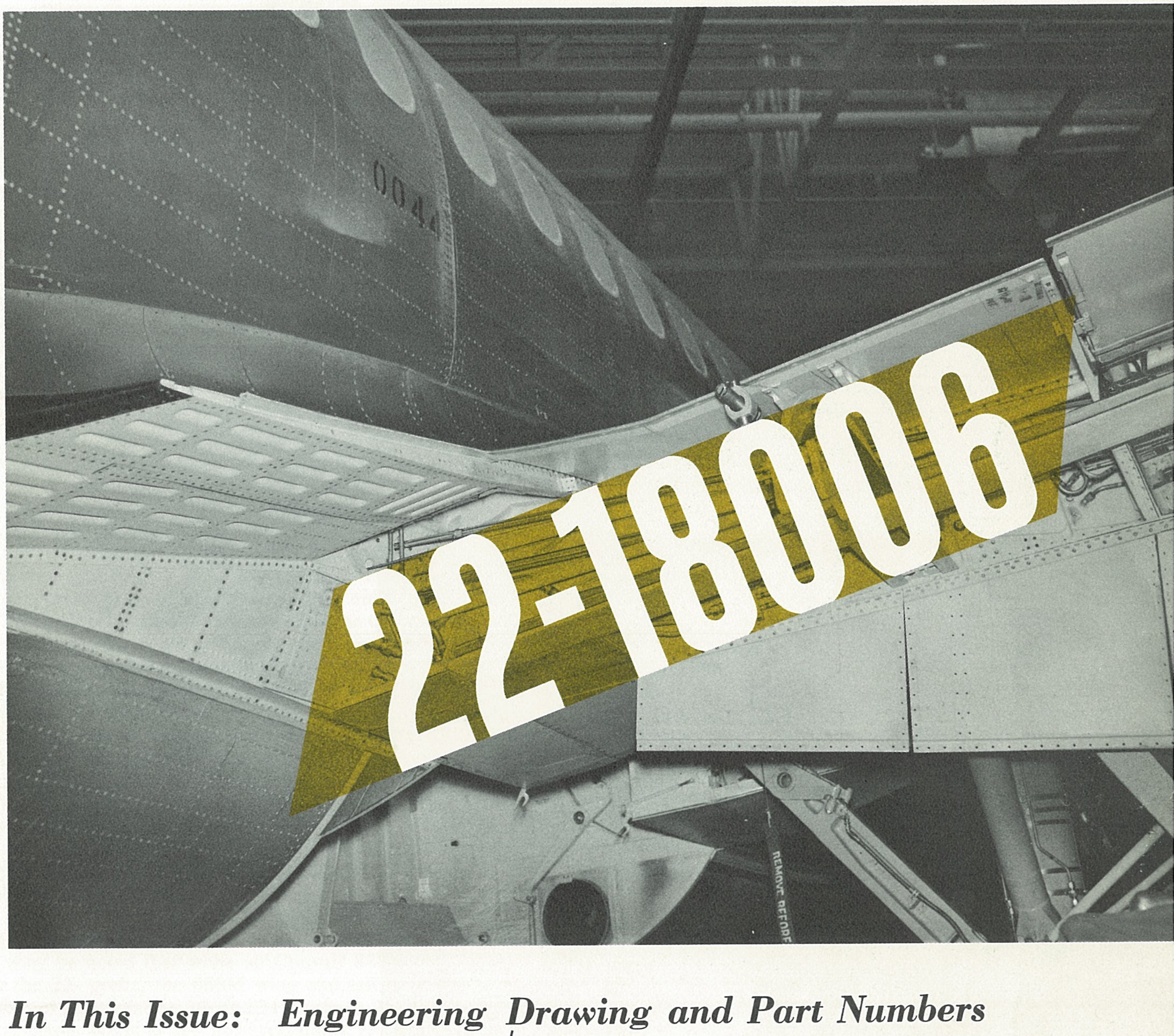
Direct all inquiries to H. R. Kennedy, Chief of Technical Publication, General Dynamics | Convair, P.O. Box 1950, San Diego 12, California.

GD

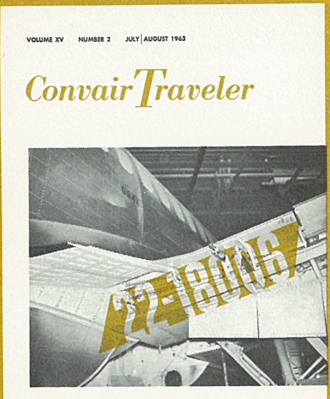
GENERAL DYNAMICS | CONVAIR

VOLUME XV NUMBER 2 JULY | AUGUST 1963

Convair Traveler



In This Issue: Engineering Drawing and Part Numbers
Convair 880 | 880M



VOLUME XV NUMBER 2 JULY|AUGUST 1963

Convair Traveler

In This Issue: *Engineering Drawing and Part Numbers Convair 880|880M*

OUR COVER

On this 880M inboard flap, Artist George Paul has boldly stenciled the part number. Since aircraft parts are rarely marked so conspicuously, George has labelled some hundreds of other 880 parts on the pages following. If he made any mistakes, please forgive him; there were a lot of labels.

Convair Traveler

VOLUME XV NUMBER 2 JULY/AUGUST 1963

MANAGER, CUSTOMER SERVICE — O. W. HARPER
CHIEF ENGINEERING SERVICE — L. J. BORDELON
CHIEF, FIELD SERVICE — R. W. SOMMERS
MANAGER, SERVICE PARTS — J. DOIG
MANAGER, TECHNICAL PUBLICATIONS — H. R. KENNEDY
EDITOR — GERTRUDE S. HUNTER

IN THIS ISSUE

PAGE 3
ENGINEERING DRAWING AND PART NUMBERS
880/880M
H. R. Smith

PAGE 14
COAXIAL CABLE CONNECTORS
N. V. Davidson

A digest of operation and service published monthly by the Technical Publications Section of GD|Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics|Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

COPYRIGHT 1963

GENERAL DYNAMICS | CONVAIR

Engineering Drawing and Part Numbers Convair 880/880M

ALMOST EVERYONE concerned with operating or maintaining aircraft has had occasion to look up the blueprint for some airplane part whose part number is unknown. Observation suggests that the procedure runs about like this: 1) ask everyone in sight if he knows the part number; 2) hunt up a Parts Catalog and skim it for a picture or a possible listing; 3) as a last resort, start through the print files—working backwards through "lists of parts" and forward through "next assemblies"— and check the "Ref" numbers, until the right number shows up. This last can be frustrating.

One soon learns his way about among the drawings of the system or area with which he is constantly concerned. But, in an unfamiliar area, one can only guess whether a mounting bracket, for example, has its own drawing number, is some rib or spar dash number, or is described in the installation drawing of whatever is mounted on it. Most baffling is to confront a row of shelves or a MID-card file of several thousand drawings with no notion of where to start.

In the latter situation, at least, the Traveler may be able to help. General pattern of the Convair jet airliner drawing number system was outlined in two previous issues of the Traveler (April 1959 and May 1960, for the Convair 880 and 990 respectively). Sketches in these issues showed airplane datum lines and planes and gave much station and dimensional information. Access doors in both 880 and 990 aircraft were identified in the issue for November-December, 1962.

Similar sketches in this issue are labeled 880/880M part numbers. The 990 will be covered in a future issue. Some installation prints are called out, particularly in furnishings and electronic equipment, but most of the numbers are airframe detail part or assembly drawings. Dash numbers appear only when there are two or more parts shown with the same basic drawing designation.

In these few pages, it is possible to show only a portion of the drawings, even those covering the Convair-built airframe. Also, there often arises the problem of locating a print covering installation of one of the hundreds of components of the airplane systems, many of them vendor parts.

The best way to short-cut a search of this kind is to start in with a general system schematic or installation print and work back from it. A list of such general drawings appears on this and the next two pages. They cover the airplane systems, and will be found to carry references to installation drawings of most system components. A possible exception is the electrical system; for a breakdown of electrical circuits and wiring, the best indexes are those in the Wiring Diagram manuals.

It may be noted that while all Convair 880 prints have the 22- prefix, the 880M wing and tail have a number of parts bearing 30- and 31- prefixes. The 990 characteristic prefix is 30-; however, many 990 drawing numbers have a 22- prefix. Reason for singling this out for particular mention is that it is easy to get lost in the wrong set of files if one forgets to note the prefix.

Model numbers appearing herein (22-3, 22-4, etc.) are cross-referenced with customer identification and registration numbers in Drawing 22-00007, and also in the Introduction to the Maintenance Manual..

The following note of caution may not be necessary, but perhaps it should be specifically stated: This array of part numbers is intended only as a quick reference guide, and should not be taken as authoritative for actual maintenance or procurement. Few dash numbers and effectivities are given; they must be checked on the prints and their associated EDP lists.

Major Drawings

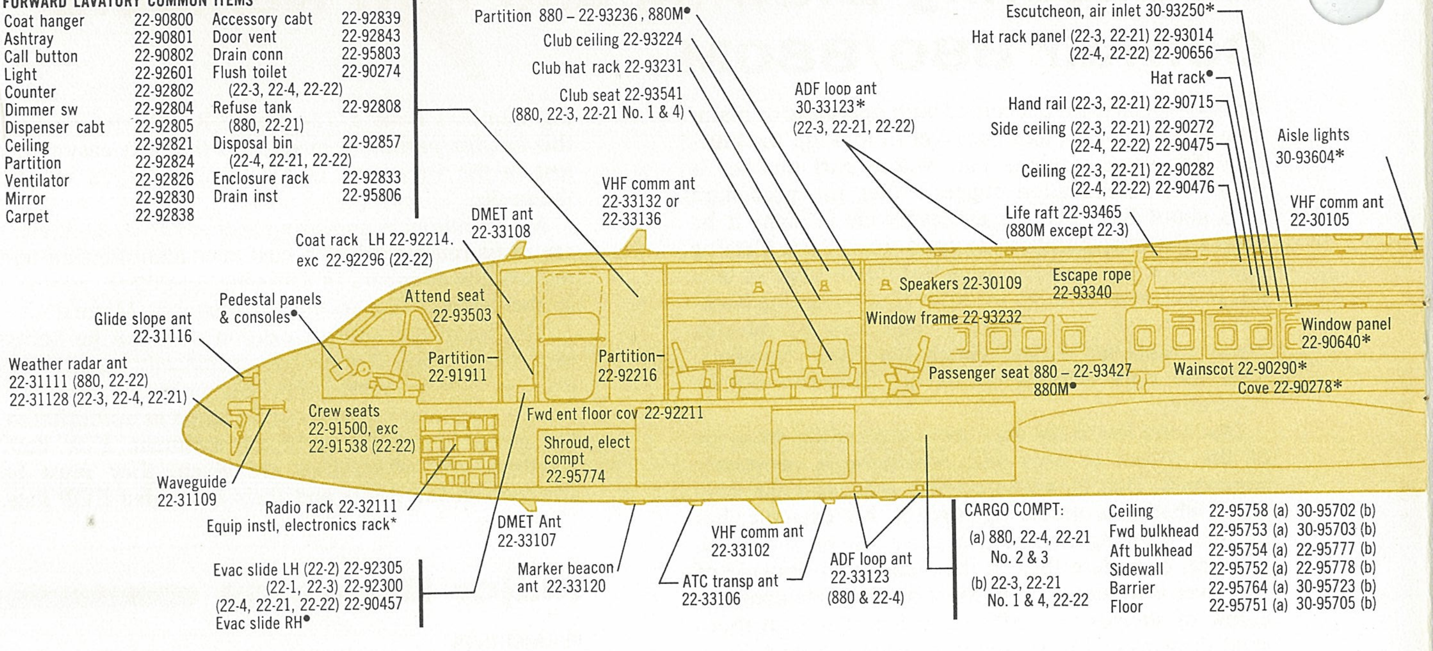
FURNISHINGS

General furnishings (list):	
880:	
Mod. 22-1	22-90001
Mod. 22-2	22-90002
880M:	
Mod. 22-3	22-90003
Mod. 22-4	22-90004
Mod. 22-21	22-90021
Mod. 22-22	22-90022
Outline (general arrangement):	
880:	
Mod. 22-1	22-90213
Mod. 22-2	22-90214
880M:	
Mod. 22-3	22-90469
Mod. 22-4	22-90647
Mod. 22-21, No. 1 & 4	22-90301
Mod. 22-21, No. 2	22-90302
Mod. 22-21, No. 3	22-90303
Mod. 22-22	22-90299
Insulation:	
Cockpit	22-90201
Cabin Sta 306-1374	22-90202
Overwing box	22-90203
Main wheel well	22-90204
Cabin air ducts — 880	22-90210
Cabin air ducts — 880M	22-90467
Placards, passenger area:	
880 & 880M (except Mod. 22-22)	22-90211
880M Mod. 22-4	22-90491
880M Mod. 22-21, No. 1 & 4	22-90662
880M Mod. 22-22	22-90664
Oxygen system:	
Installation:	
880 (all)	22-90400
880M, Mod. 22-3	22-90298
880M, Mod. 22-4	22-90434
880M, Mod. 22-21	22-90762
880M, Mod. 22-22	22-90731
Schematic (all)	22-90401
Pitot-static system:	
Installation	22-90403
Schematic	22-90404
Water equipment:	
Installation	22-90410
Schematic	22-95411
Lavatory plumbing diagram	22-95813
Exterior lights installation	22-90610

Furnishings and Electronic Equipment

FORWARD LAVATORY COMMON ITEMS

Coat hanger	22-90800	Accessory cabt	22-92839
Ashtray	22-90801	Door vent	22-92843
Call button	22-90802	Drain conn	22-95803
Light	22-92601	Flush toilet (22-3, 22-4, 22-22)	22-90274
Counter	22-92802		
Dimmer sw	22-92804	Refuse tank (880, 22-21)	22-92808
Dispenser cabt	22-92805		
Ceiling	22-92821	Disposal bin (22-4, 22-21, 22-22)	22-92857
Partition	22-92824		
Ventilator	22-92826	Enclosure rack	22-92833
Mirror	22-92830	Drain inst	22-95806
Carpet	22-92838		



CARGO COMPT:

(a) 880, 22-4, 22-21 No. 2 & 3

(b) 22-3, 22-21 No. 1 & 4, 22-22

Ceiling	22-95758 (a)	30-95702 (b)
Fwd bulkhead	22-95753 (a)	30-95703 (b)
Aft bulkhead	22-95754 (a)	22-95777 (b)
Sidewall	22-95752 (a)	22-95778 (b)
Barrier	22-95764 (a)	30-95723 (b)
Floor	22-95751 (a)	30-95705 (b)

ELECTRONIC EQUIPMENT

General arrangement:	
880:	
Mod. 22-1	22-30001
Mod. 22-2	22-30002
880M:	
Mod. 22-3	22-30003
Mod. 22-4	22-30004
Mod. 22-21	22-30021
Mod. 22-22	22-30022
Equipment installation, electronics rack:	
880:	
Mod. 22-1	22-32115
Mod. 22-2	22-32116
880M:	
Mod. 22-3	22-32114
Mod. 22-4	22-32133
Mod. 22-21	22-32134
Mod. 22-22	22-32135

AIR CONDITIONING & PRESSURIZATION

System installation	22-29000
Schematics:	
880 Mod. 22-1	22-02001
880 Mod. 22-2	22-02000
880M Mod. 22-3, 22-4, 22-21 No. 2 & 3	22-02003
880M Mod. 22-21 No. 1 & 4, 22-22	22-02021
Equipment installation underwing	22-29003
Low-pressure pneumatic tubing isometric	22-20000
Ducting:	
Under floor	22-28023
Cabin air supply — 880	22-28067 22-28054
Cabin air supply — 880M	22-28067 22-28079
Flight compartment	22-28000
Wing bleed air — 880	22-27119
Wing bleed air — 880M	31-27119
Rainclearing	22-27104 22-27105
Rainclearing — 880 Mod. 22-2	22-27103
Underwing bleed air	22-29011
Electronic cooling	22-28090
Pylon	22-27000
Overheat detection system:	
Wing bleed air duct	22-27052
Wing duct space — 880 & 880M	22-27053
Wing duct space — 880M	31-27052
Rainclearing duct space	22-27055
Underwing duct space (pneu Freon systems)	22-27056
Pylon	22-24607

CONTROLS

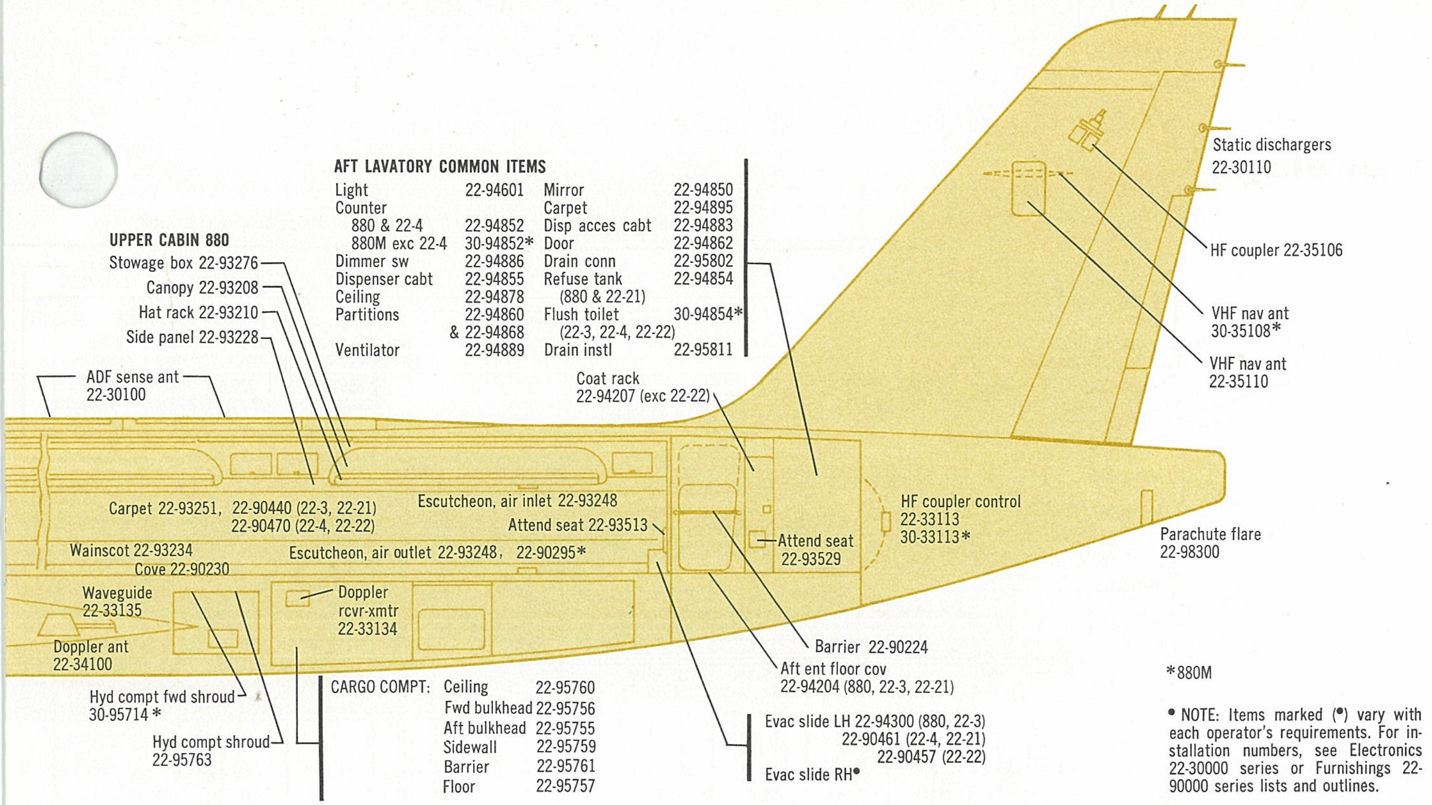
Control systems — general	22-40000
Slats (880M)	30-40001
Rudder	22-40002
Elevator	22-40003
Aileron-spoiler-speedbrakes	22-40004
Flaps	22-40005
Rudder trim	22-40006
Engine	22-40007
Autopilot	22-40008
Landing gear	22-40010
Nose wheel steering	22-40011
Brakes	22-40012
Landing gear emergency extension	22-40013
Stabilizer trim	22-40016
Aileron trim	22-40017
Fairleads	22-40009
Cable assembly	22-40911
Control column installation	22-41000
Pedestal installation	22-41001
Landing gear lever	22-41005
Parking hand brake	22-41004
Rudder pedal installation	22-41200

FUEL SYSTEM

System schematics:	
880	22-21440
880M Mod. 22-4, 22-21 No. 1, 2 & 4, 22-22	22-21449
880M Mod. 22-3, 22-21 No. 3	22-21440
Subsystem installation:	
Engine fuel supply	22-21400
Refuel-defuel	22-21470
Fuel gaging	22-21450
Vent	22-21500
Jettison	22-21550

HYDRAULICS

Hydraulic equipment installation	22-85000
Schematics:	
System 1:	
880 Model 22-1	22-80001
880 Model 22-2	22-80003
System 2:	
880 Model 22-1	22-80002


UPPER CABIN 880
Stowage box 22-93276
Canopy 22-93208
Hat rack 22-93210
Side panel 22-93228
ADF sense ant 22-30100
Coat rack 22-94207 (exc 22-22)
Static dischargers 22-30110
HF coupler 22-35106
VHF nav ant 30-35108*
VHF nav ant 22-35110
Carpet 22-93251, 22-90440 (22-3, 22-21) 22-90470 (22-4, 22-22)
Escutcheon, air inlet 22-93248
Attend seat 22-93513
Wainscot 22-93234
Escutcheon, air outlet 22-93248, 22-90295*
Cove 22-90230
Attend seat 22-93529
HF coupler control 22-33113 30-33113*
Parachute flare 22-98300
Waveguide 22-33135
Doppler rcvr-xmtr 22-33134
Doppler ant 22-34100
Barrier 22-90224
Aft ent floor cov 22-94204 (880, 22-3, 22-21)
Hyd compt fwd shroud 30-95714*
Hyd compt shroud 22-95763
Evac slide LH 22-94300 (880, 22-3) 22-90461 (22-4, 22-21) 22-90457 (22-22)
Evac slide RH•

AFT LAVATORY COMMON ITEMS

Light	22-94601	Mirror	22-94850
Counter		Carpet	22-94895
880 & 22-4	22-94852	Disp acces cabt	22-94883
880M exc 22-4	30-94852*	Door	22-94862
Dimmer sw	22-94886	Drain conn	22-95802
Dispenser cabt	22-94855	Refuse tank (880 & 22-21)	22-94854
Ceiling	22-94878		
Partitions	22-94860 & 22-94868	Flush toilet (22-3, 22-4, 22-22)	30-94854*
Ventilator	22-94889	Drain instl	22-95811

CARGO COMPT:

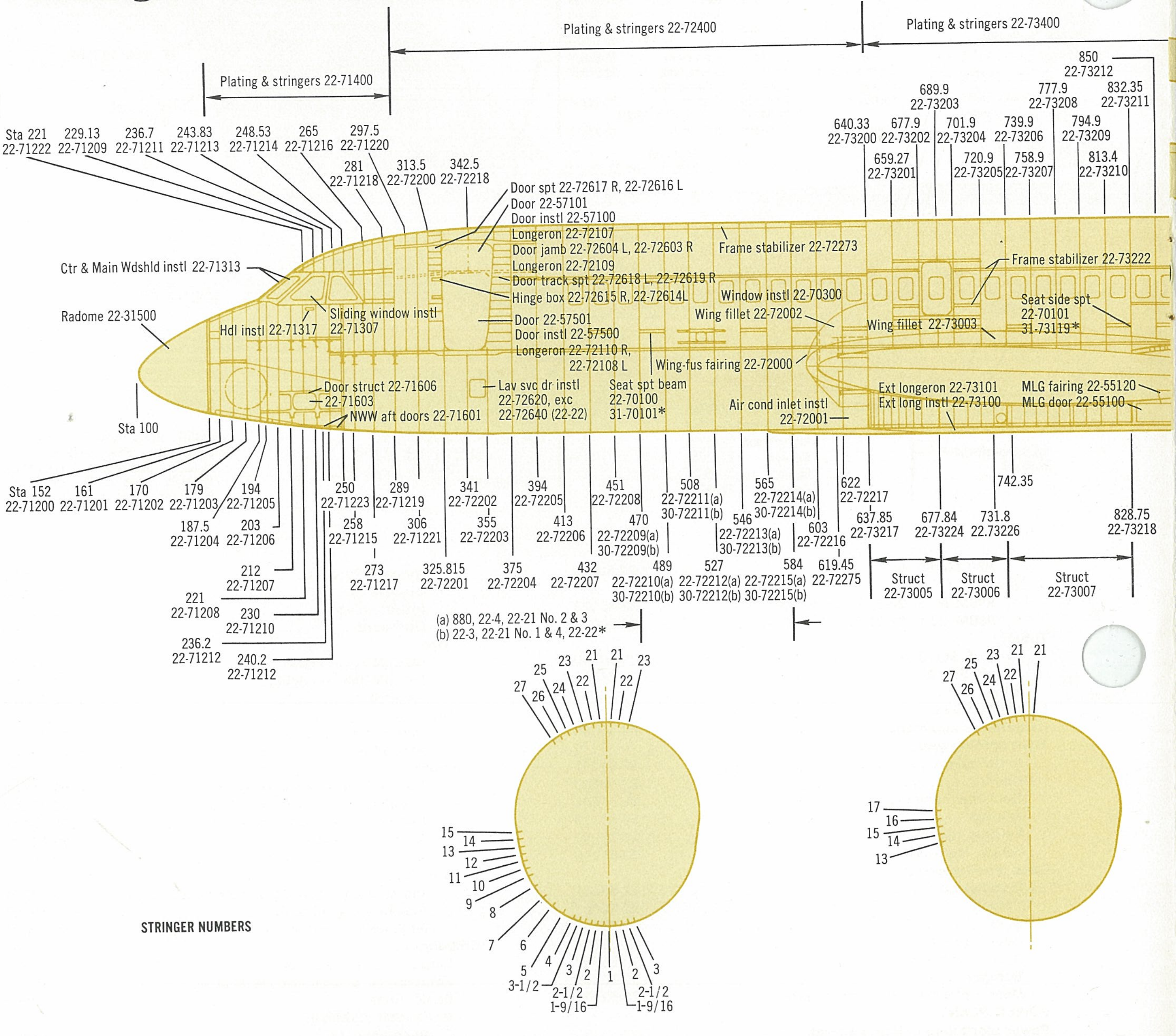
Ceiling	22-95760
Fwd bulkhead	22-95756
Aft bulkhead	22-95755
Sidewall	22-95759
Barrier	22-95761
Floor	22-95757

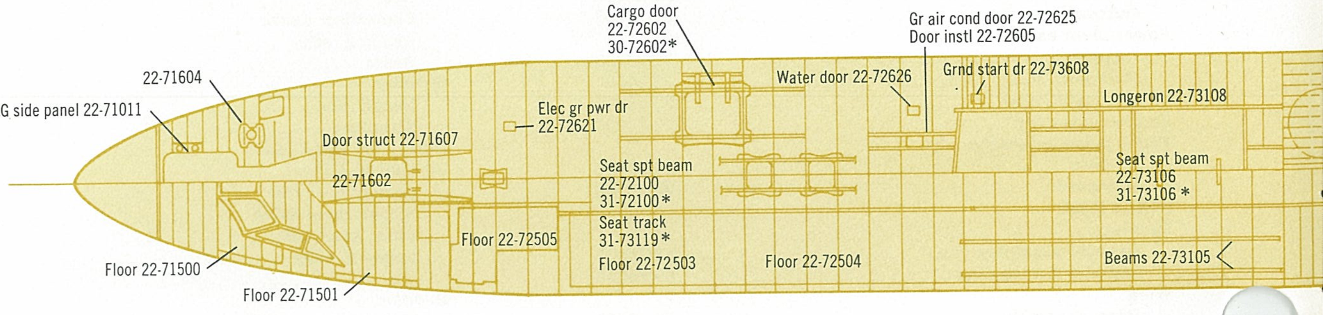
*880M

• NOTE: Items marked (•) vary with each operator's requirements. For installation numbers, see Electronics 22-30000 series or Furnishings 22-90000 series lists and outlines.

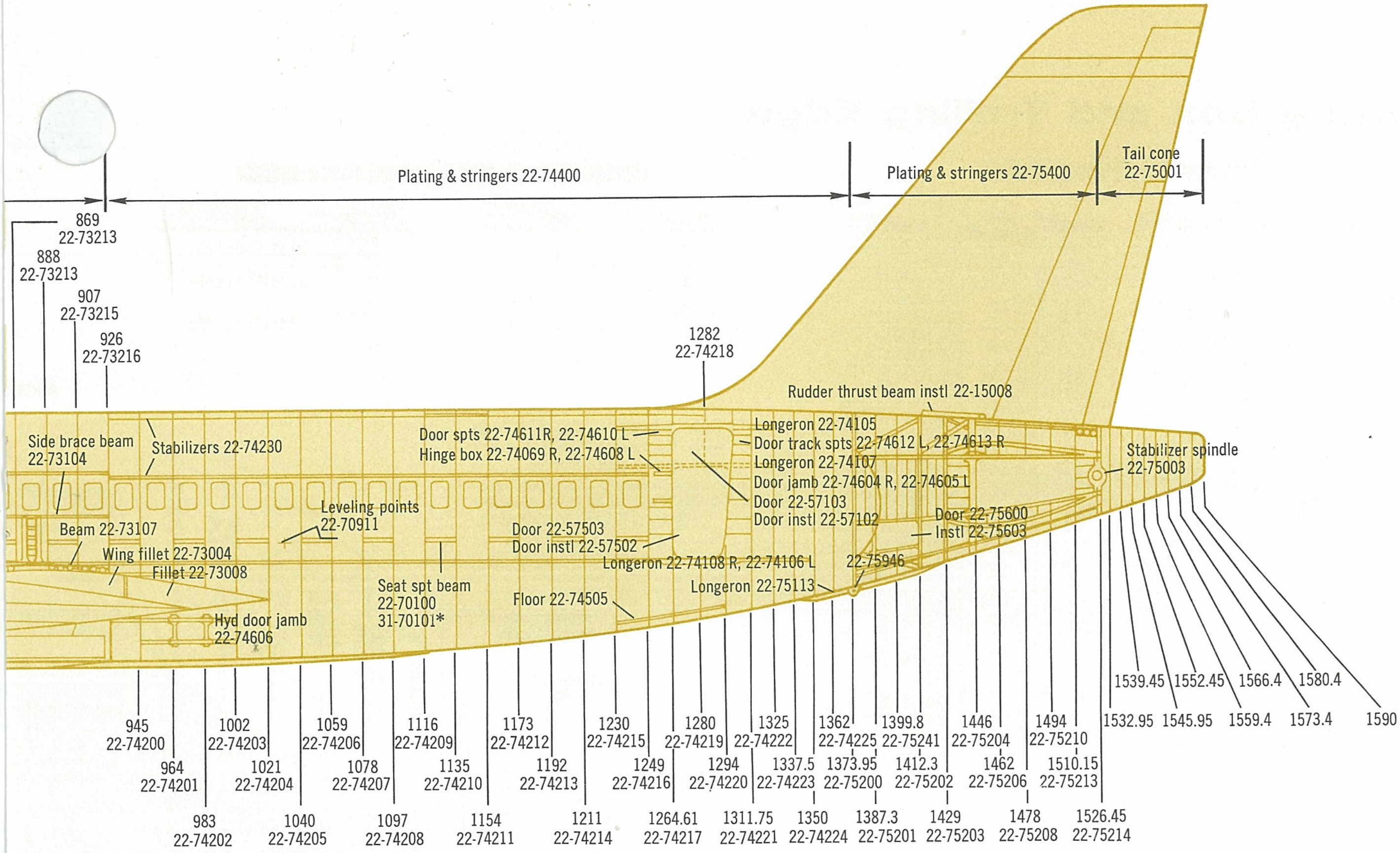
880 Model 22-2	22-80004
Systems 1 & 2:	
880M Mod. 22-3, 22-21 No. 3	22-80023
880M 22-4, 22-21 No. 1, 2 & 4, 22-22	22-80024
Tubing:	
Fwd of Sta 926	22-80100
Aft of Sta 926	22-80102
Wing	22-80103
LANDING GEAR	
General arrangement	22-50000
Main landing gear:	
Installation	22-51001
Door	22-55100
Door mechanisms	22-55101
Fairing	22-55120
Fairing uplock	22-55150
Hinge installation	22-55195
Nose landing gear:	
Installation	22-52001
Uplock	22-52002
Door	22-71600
Door uplock	22-52004
Door mechanism	22-55500
Bumper	22-52003
Door uplock emergency release	22-52005
POWER PLANT	
Power plant installation, general:	
Inboard	22-21000
Outboard	22-21002
Power plant assembly:	
Inboard	22-24000
Outboard	22-24002
Engine installation	22-23000
Engine assembly	22-22000
Pod & pylon assembly:	
Inboard	22-25000
Outboard	22-25002
STRUCTURE	
Fuselage:	
General assembly (list)	22-70001
General arrangement	22-70005
Wing:	
Wing assembly	22-16000
Box section	22-16001
Center tie box	22-16020
Trailing edge:	
Inboard forward	22-16005
Inboard aft	22-16006
Intermediate	22-16007
Outboard	22-16008
Tip:	
Installation — 880	22-19000
Installation — 880M	31-19000
Assembly	22-19050
Aileron:	
Installation	22-17000
Assembly	22-17001
Flaps:	
Installation — inboard — 880	22-18000
Installation — inboard — 880M	22-19205
Installation — outboard — all	22-18001
Assembly — inboard	22-18006
Assembly — outboard	22-18007
Spoilers:	
Installation, inboard & outboard	22-19500
Assembly — inboard	22-19007
Assembly — outboard	22-19006
Empennage:	
Empennage installation	22-10010
Empennage equipment installation	22-10011
Basic lines	22-10850
Horizontal stabilizer:	
Assembly	22-11000
Spar box	22-11002
Centerline splice	22-11003
Leading edge	22-14004
Boom	22-11914
Elevator:	
Installation	22-12000
Structure	22-12001
Dorsal fin installation	22-13000
Vertical stabilizer:	
Structure — 880	22-14000
Structure — 880M	30-14000
Inner spar box	22-14002
Leading edge	22-14900
Tip	22-14900
Rudder:	
Installation — 880	22-15000
Installation — 880M	30-15000
Structure — 880	22-15001
Structure — 880M	30-15001

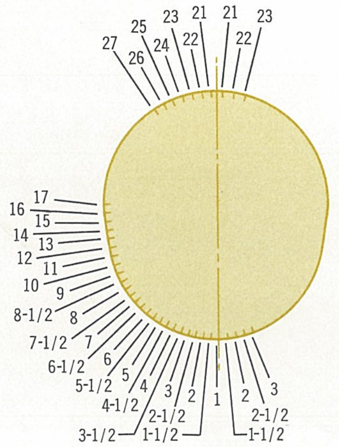
Fuselage

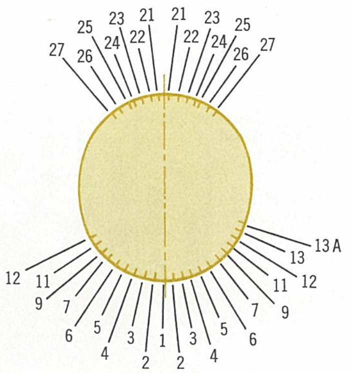


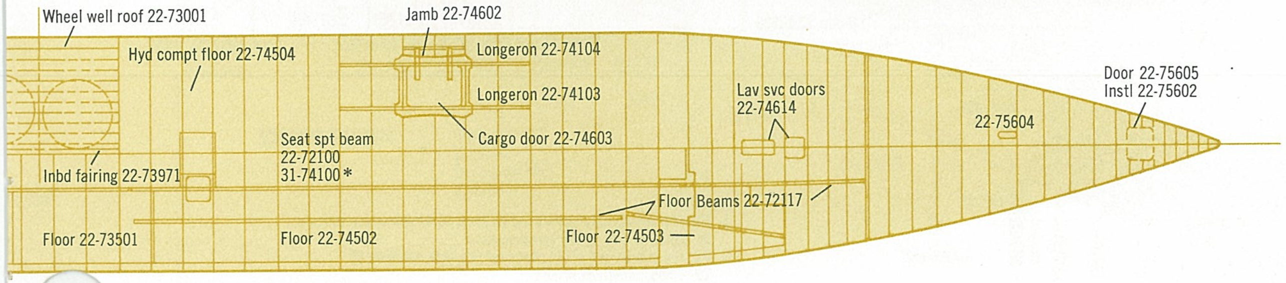


PLAN VIEW


Plating & stringers 22-74400
Plating & stringers 22-75400
Tail cone 22-75001
869 22-73213
888 22-73213
907 22-73215
926 22-73216
1282 22-74218
Rudder thrust beam instl 22-15008
Side brace beam 22-73104
Stabilizers 22-74230
Door spts 22-74611R, 22-74610 L
Hinge box 22-74069 R, 22-74608 L
Longeron 22-74105
Door track spts 22-74612 L, 22-74613 R
Longeron 22-74107
Door jamb 22-74604 R, 22-74605 L
Door 22-57103
Door instl 22-57102
Stabilizer spindle 22-75003
Leveling points 22-70911
Beam 22-73107
Wing fillet 22-73004
Fillet 22-73008
Door 22-57503
Door instl 22-57502
Door 22-75600
Instl 22-75603
Longeron 22-74108 R, 22-74106 L
22-75946
Longeron 22-75113
Seat spt beam 22-70100 31-70101*
Floor 22-74505
Hyd door jamb 22-74606
945 22-74200
964 22-74201
983 22-74202
1002 22-74203
1021 22-74204
1040 22-74205
1059 22-74206
1078 22-74207
1097 22-74208
1116 22-74209
1135 22-74210
1154 22-74211
1173 22-74212
1192 22-74213
1211 22-74214
1230 22-74215
1249 22-74216
1264.61 22-74217
1280 22-74219
1294 22-74220
1311.75 22-74221
1325 22-74222
1337.5 22-74223
1350 22-74224
1362 22-74225
1373.95 22-75200
1387.3 22-75201
1399.8 22-75241
1412.3 22-75202
1429 22-75203
1446 22-75204
1462 22-75206
1478 22-75208
1494 22-75210
1510.15 22-75213
1526.45 22-75214
1532.95
1539.45
1545.95
1552.45
1559.4
1566.4
1573.4
1580.4
1590


8-1/2
7-1/2
6-1/2
5-1/2
4-1/2
3-1/2
2-1/2
1-1/2
2-1/2
1-1/2


13 A


Wheel well roof 22-73001
Hyd compt floor 22-74504
Jamb 22-74602
Longeron 22-74104
Longeron 22-74103
Cargo door 22-74603
Seat spt beam 22-72100 31-74100*
Inbd fairing 22-73971
Lav svc doors 22-74614
Door 22-75605
Instl 22-75602
22-75604
Floor Beams 22-72117
Floor 22-73501
Floor 22-74502
Floor 22-74503

Wing Box and Trailing Edge

STRINGERS — WING LOWER SURFACE

STRINGER	SPAN BLKHD NO.	PART
1	1-4	22-16171-7
2	1-7	22-16171-43
3	1-8	22-16175-35
	8-14	22-16179-7
4	1-8	22-16171-37
	8-20	22-16179-9
5	1-8	22-16171-41
	8-23	22-16179-41
	23-27	22-16175-7
6	1-2	22-16157-11
	3-8	22-16161-39
	8-23	22-16179-43
	23-24	22-16175-9
7	1-8	22-16171-11
	8-13	22-16179-29
	14-16	22-16179-37 (R&L)
	17-19	22-16179-35 (R&L)
	20-21	22-16179-33 (R&L)
	24-25	22-16175-11
	27-36	22-16175-19
8	1-8	22-16171-13
	8-23	22-16179-45
	23-36	22-16175-21
9	1-4	22-16171-17 22-16171-45*
10	1-7	22-16171-19 22-16171-47*
11	1-8	22-16171-21 22-16171-49*
11	8-23	22-16179-15
	23-36	22-16176-19
12	1-2	22-16158-7 22-16158-15*
	3-8	22-16158-9 22-16158-17*
	8-13	22-16179-21
	17-19	22-16179-19 (R&L)
	20-21	22-16179-17 (R&L)
	25-26	22-16176-13
	27-36	22-16176-23
13	1-8	22-16171-23 22-16171-51*
	8-23	22-16179-23
	23-35	22-16176-11
14	1-8	22-16158-11 22-16158-19*
	8-23	22-16179-39
	23-29	22-16176-15
15	1-8	22-16158-13 22-16158-21*
	8-22	22-16179-11
16	1-8	22-16171-25 22-16171-53*
	8-16	22-16179-13
17	1-6	22-16171-73 22-16171-55*

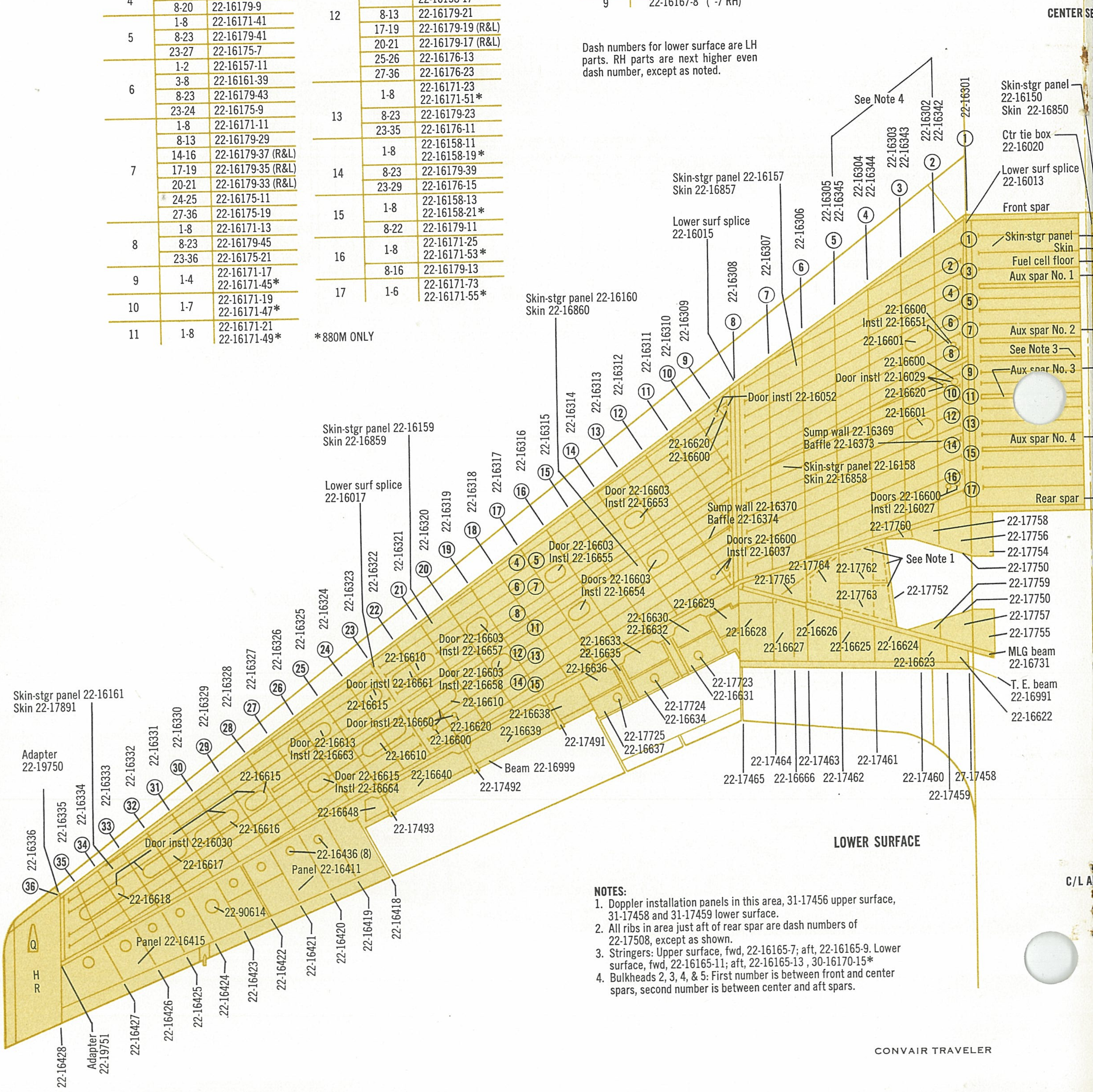
*880M ONLY

STRINGERS — WING CENTER SECTION LOWER SURFACE

STRINGER	PART
1	22-16164-7
2	
3	
5	22-16167-9 (-10 RH)
6	22-16167-10 (-9 RH)
7	22-16167-9 (-10 RH)
9	22-16167-8 (-7 RH)

STRINGER	PART
10	22-16167-8 (-7 RH)
12	
13	22-16167-7 (-8 RH)
14	22-16167-8 (-7 RH)
16	
17	

Dash numbers for lower surface are LH parts. RH parts are next higher even dash number, except as noted.



NOTES:

1. Doppler installation panels in this area, 31-17456 upper surface, 31-17458 and 31-17459 lower surface.
2. All ribs in area just aft of rear spar are dash numbers of 22-17508, except as shown.
3. Stringers: Upper surface, fwd, 22-16165-7; aft, 22-16165-9. Lower surface, fwd, 22-16165-11; aft, 22-16165-13 , 30-16170-15*
4. Bulkheads 2, 3, 4, & 5: First number is between front and center spars, second number is between center and aft spars.

STRINGERS — WING CENTER SECTION UPPER SURFACE

STRINGER	PART
1	22-16150-8
2	22-16166-10
3	22-16150-8
5	
6	
7	
8	
9	
11	22-16150-10

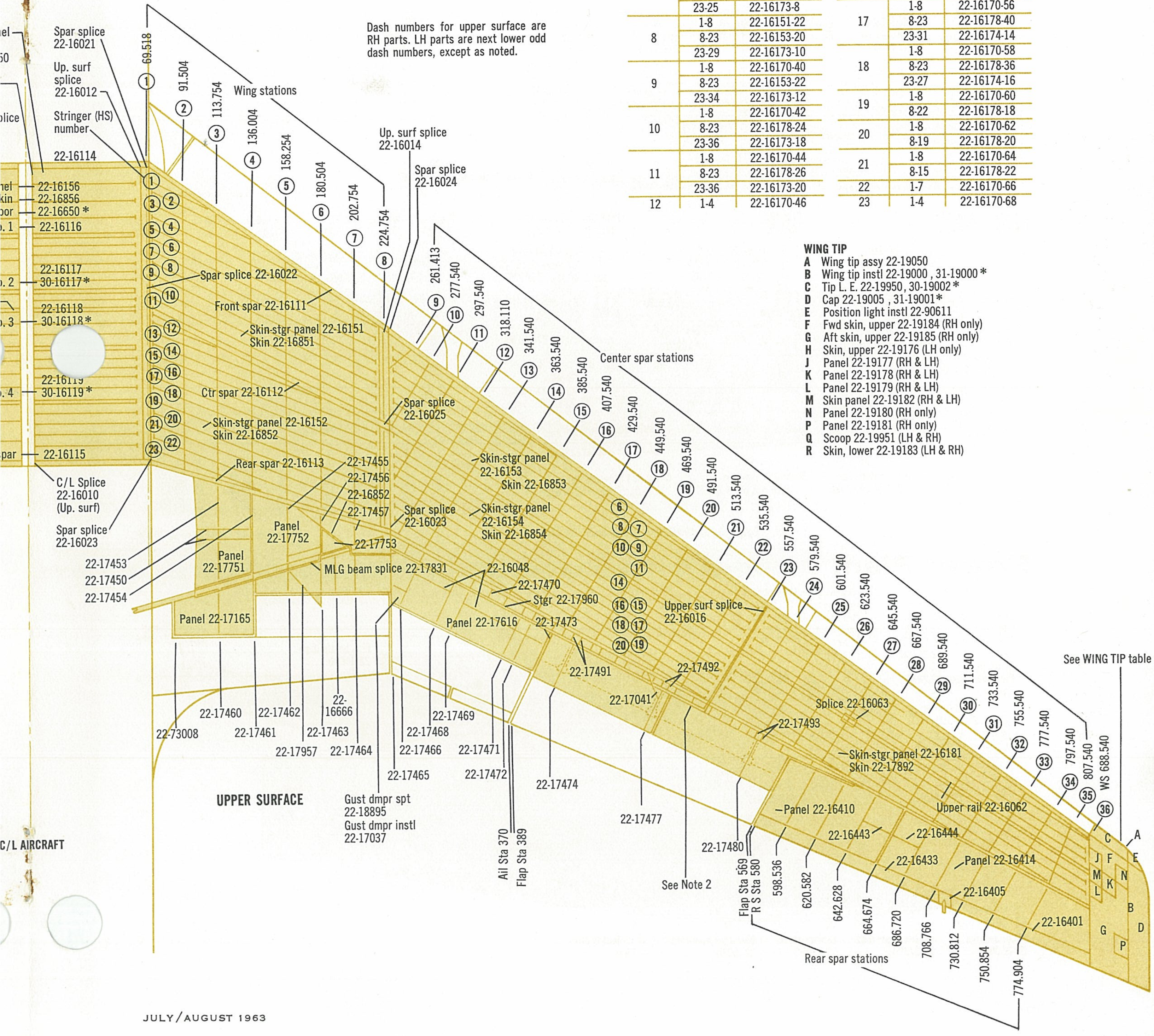
STRINGER	PART
12	22-16150-10
13	
15	
16	
17	
18	
20	
21	
22	
23	

STRINGERS — WING UPPER SURFACE

STRINGER	SPAN BLKHD NO.	PART
1	1-2	22-16170-8
2	1-5	22-16170-10
3	1-7	22-16170-70
4	1-8	22-16170-14
5	1-8	22-16151-20
	8-15	22-16178-8
6	1-8	22-16151-18
	8-20	22-16178-10
7	1-8	22-16151-24
	8-23	22-16153-18
	23-25	22-16173-8
8	1-8	22-16151-22
	8-23	22-16153-20
	23-29	22-16173-10
9	1-8	22-16170-40
	8-23	22-16153-22
	23-34	22-16173-12
10	1-8	22-16170-42
	8-23	22-16178-24
	23-36	22-16173-18
11	1-8	22-16170-44
	8-23	22-16178-26
	23-36	22-16173-20
12	1-4	22-16170-46

STRINGER	SPAN BLKHD NO.	PART
13	1-7	22-16170-48
14	1-8	22-16170-50
	8-23	22-16178-28
	23-36	22-16174-18
15	1-8	22-16170-52
	8-23	22-16178-30
	23-36	22-16174-20
16	1-8	22-16170-54
	8-23	22-16178-32
	23-35	22-16174-12
17	1-8	22-16170-56
	8-23	22-16178-40
	23-31	22-16174-14
18	1-8	22-16170-58
	8-23	22-16178-36
	23-27	22-16174-16
19	1-8	22-16170-60
	8-22	22-16178-18
20	1-8	22-16170-62
	8-19	22-16178-20
21	1-8	22-16170-64
	8-15	22-16178-22
22	1-7	22-16170-66
23	1-4	22-16170-68

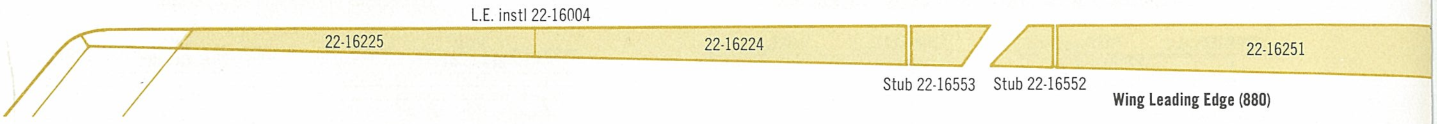
Dash numbers for upper surface are RH parts. LH parts are next lower odd dash numbers, except as noted.



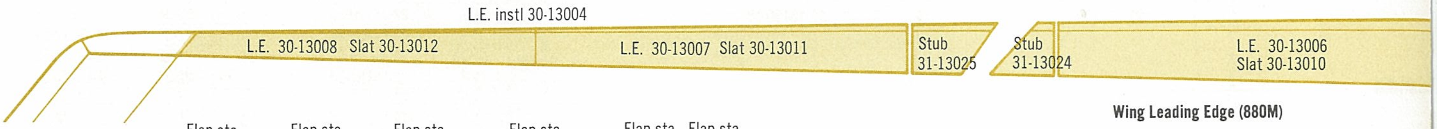
WING TIP

A	Wing tip assy 22-19050
B	Wing tip instl 22-19000 , 31-19000 *
C	Tip L. E. 22-19950, 30-19002 *
D	Cap 22-19005 , 31-19001 *
E	Position light instl 22-90611
F	Fwd skin, upper 22-19184 (RH only)
G	Aft skin, upper 22-19185 (RH only)
H	Skin, upper 22-19176 (LH only)
J	Panel 22-19177 (RH & LH)
K	Panel 22-19178 (RH & LH)
L	Panel 22-19179 (RH & LH)
M	Skin panel 22-19182 (RH & LH)
N	Panel 22-19180 (RH only)
P	Panel 22-19181 (RH only)
Q	Scoop 22-19951 (LH & RH)
R	Skin, lower 22-19183 (LH & RH)

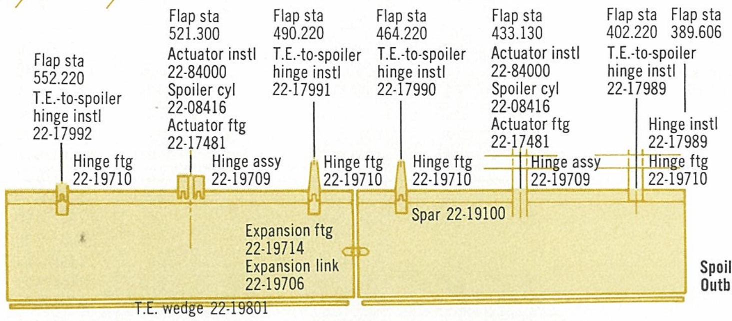
Wing Leading Edge and Flight Controls



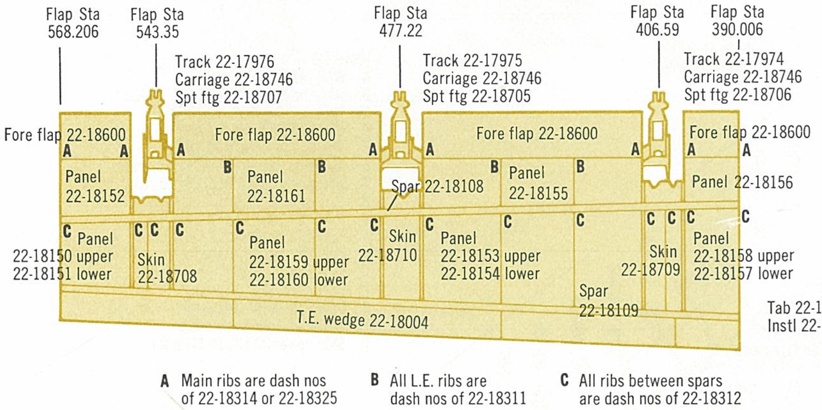
Wing Leading Edge (880)


L.E. instl 30-13004
L.E. 30-13008 Slat 30-13012
L.E. 30-13007 Slat 30-13011
Stub 31-13025
Stub 31-13024
L.E. 30-13006 Slat 30-13010

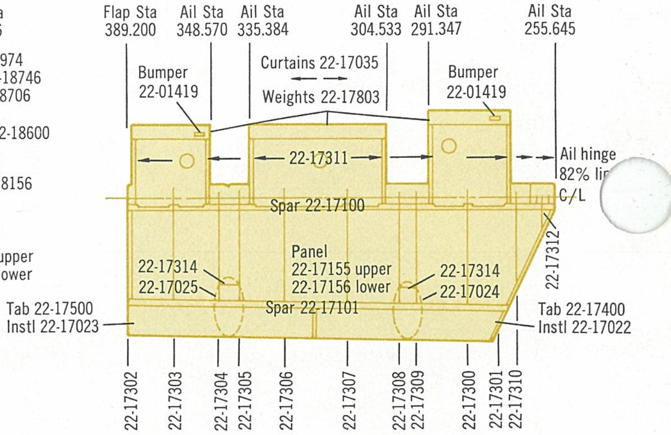
Wing Leading Edge (880M)



Spoiler Instl 22-19500
Outbd Spoiler Assy 22-19006



Outbd flap 22-18007 (880, 880M) Instl 22-18001



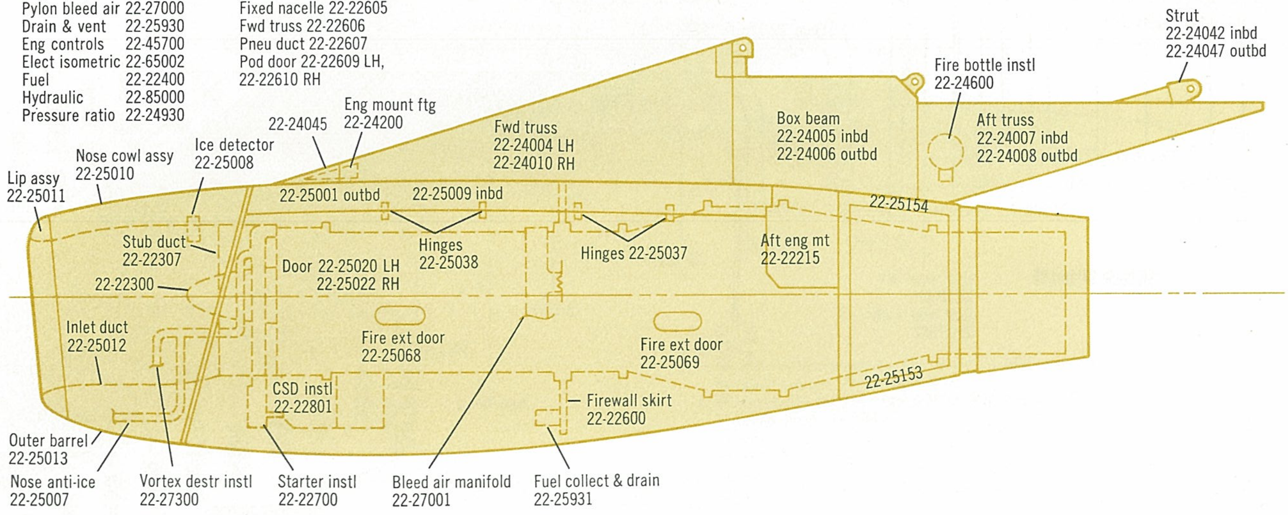
Aileron 22-17001 Instl 22-17000

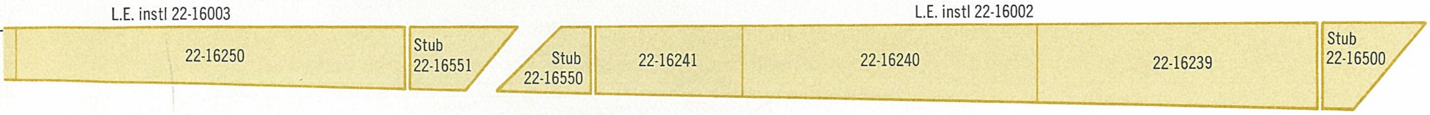
Power Plant

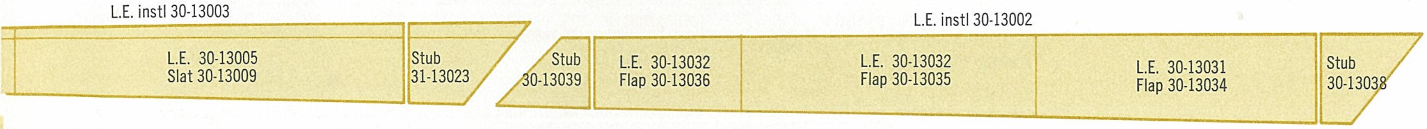
Pod Pylon Systems

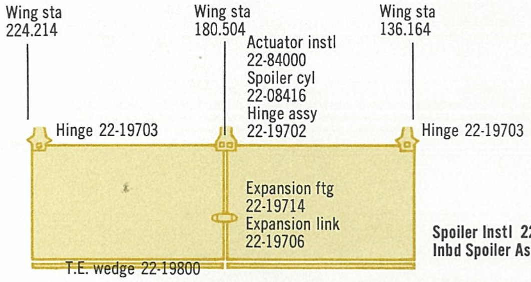
Pylon bleed air	22-27000
Drain & vent	22-25930
Eng controls	22-45700
Elect isometric	22-65002
Fuel	22-22400
Hydraulic	22-85000
Pressure ratio	22-24930

Fire & ovht detector loops
Fixed nacelle 22-22605
Fwd truss 22-22606
Pneu duct 22-22607
Pod door 22-22609 LH, 22-22610 RH

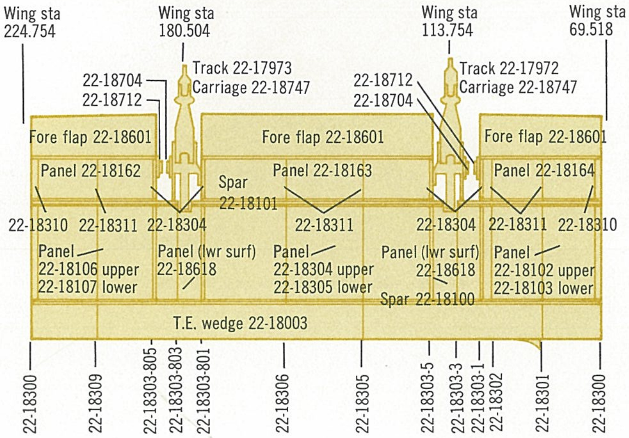




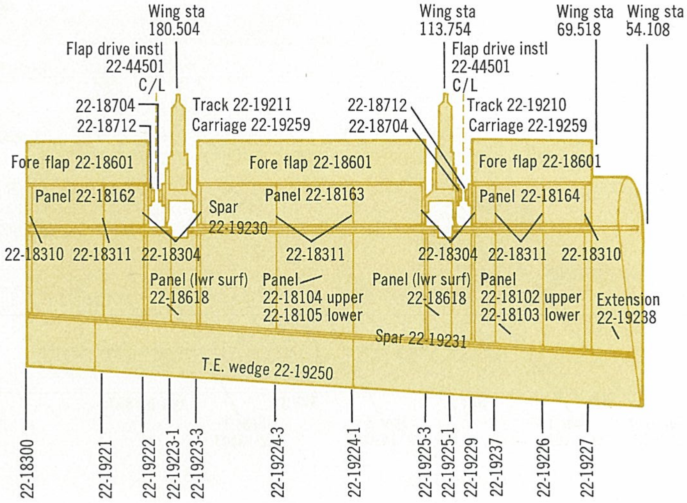




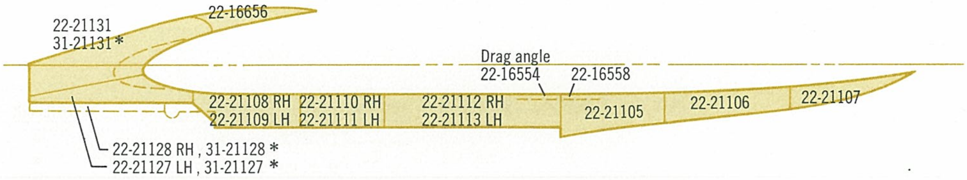
Spoiler Instl 22-19500
Inbd Spoiler Assy 22-19007



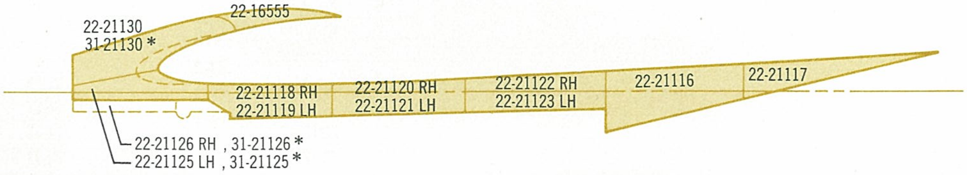
Inbd flap 22-18006 (880) Instl 22-18000



Inbd flap 22-18006 (880M) Instl 22-19205

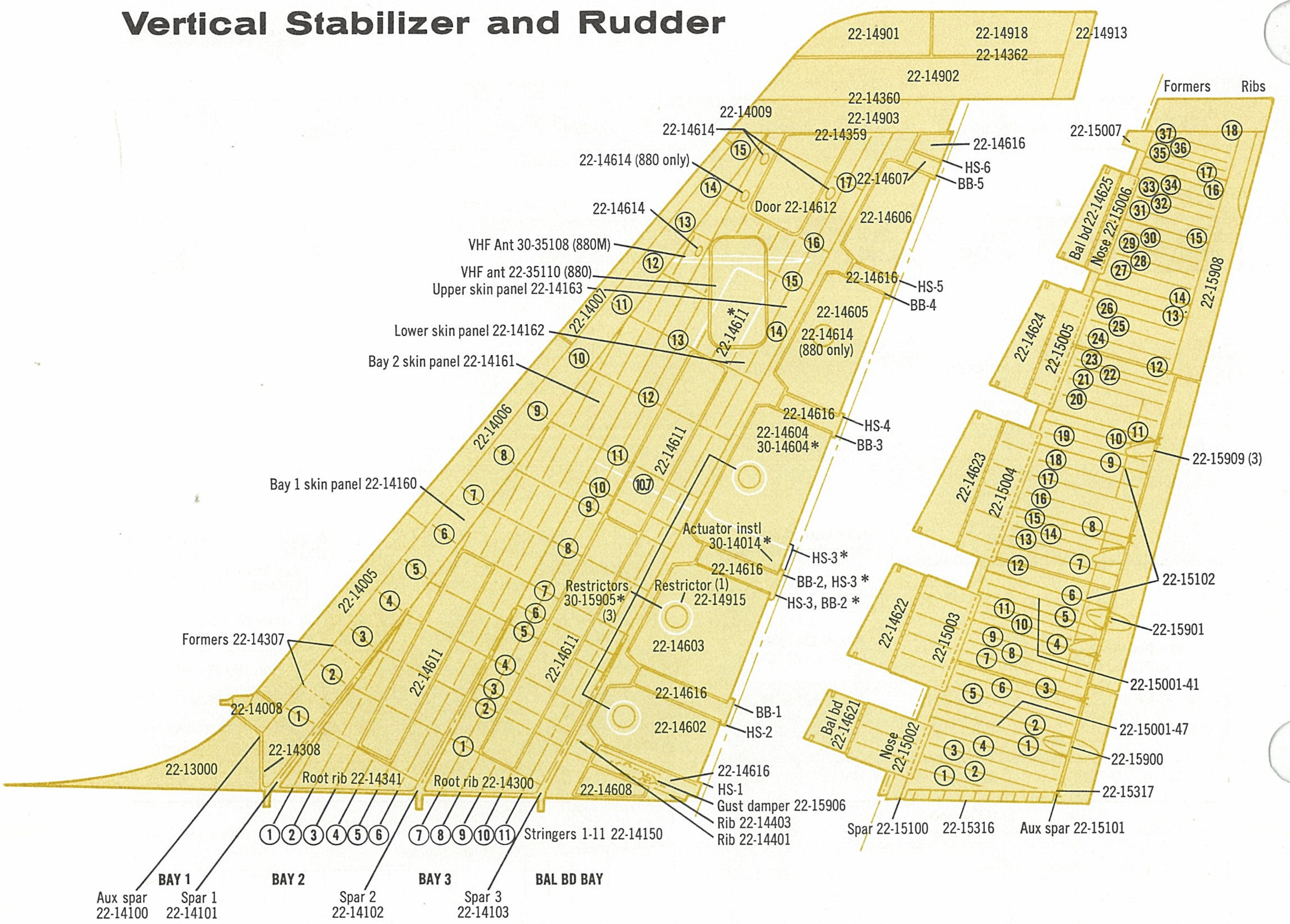


Pylon Fairing Panel Instl — Inbd 22-21100 * 880M



Pylon Fairing Panel Instl — Outbd 22-21002 * 880M

Vertical Stabilizer and Rudder



Horizontal Stabilizer and Elevator

RIBS and FORMERS — ELEVATOR

NUMBER	RIB	FORMER
1	22-12301	22-12310
2	22-12302	
3		22-12316
4	22-12303	
5		22-12311
6	22-12304	
7	22-12306	22-12316
8	22-12304	22-12312
9	22-12305	
10		22-12313
11	22-12306	
12	22-12307	22-12314

NUMBER	RIB	FORMER
13	22-12307	22-12314
14		
15		
16	22-12309	22-12315
17	22-12308	
18		
19	22-12309	
20	22-12301	22-12317
21-23		
24-27		22-12318
28-31		22-12319
32-37		22-12320

RIBS and FORMERS — RUDDER

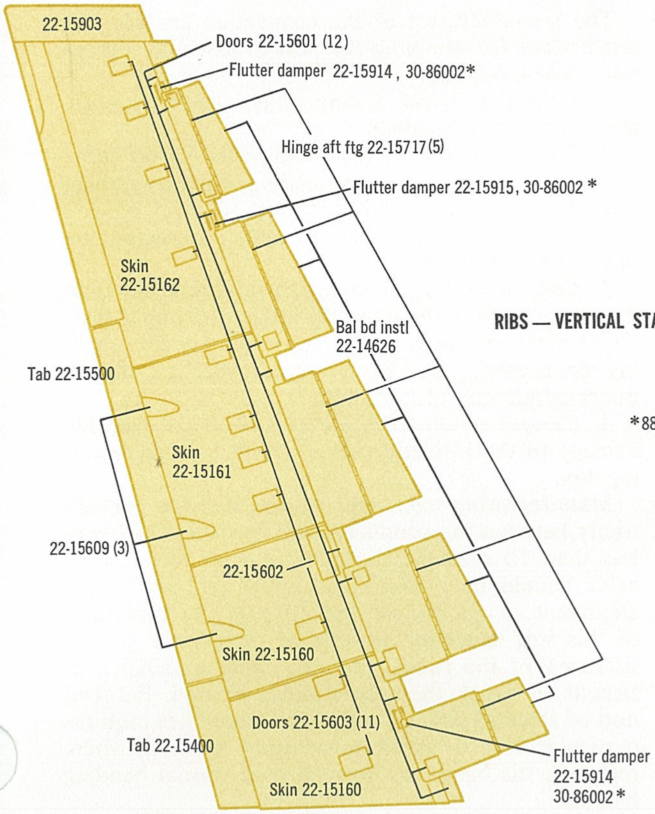
RIB	DRAWING
1	22-15301
2	22-15302
3	22-15303
4	22-15304
5	22-15305
6	22-15306
7	22-15307
8	22-15307
9	22-15308
10	22-15309
11	22-15309
12	22-15312
13	22-15311
14	22-15311
15	22-15310
16	22-15313
17	22-15313
18	22-15313

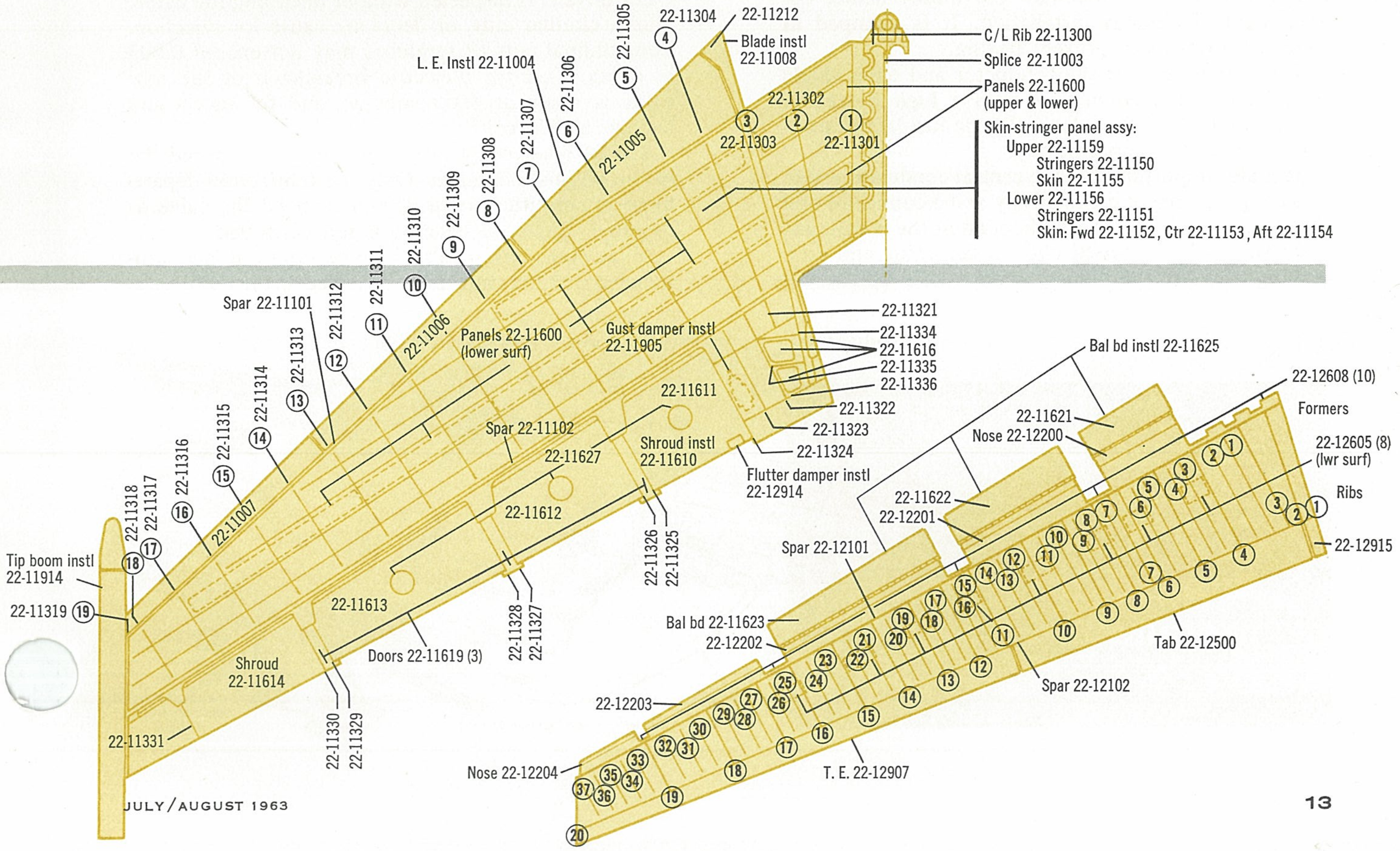
FORMER	DRAWING
1, 2, 3, 4	22-15350
5, 6, 7	22-15351
8, 9, 10	22-15352
11, 12	22-15353
13, 14, 15	22-15354
16, 17, 18	22-15355
19	22-15356
20, 21, 22	22-15357
23, 24, 25	22-15358
26, 27	22-15359
28, 29, 30	22-15360
31, 32, 33, 34	22-15361
35, 36, 37	22-15362

RIBS — VERTICAL STABILIZER

*880M ONLY

RIB	BAY 1	BAY 2	BAY 3	HINGE SUPPORT (HS)	BAL BD SEAL (BB)
1	22-14301	22-14321	22-14342	22-14404	22-14407
2	22-14302	22-14322	22-14343	22-14406	22-14411 30-14301*
3		22-14323	22-14344	22-14410 30-14302 Lower* 30-14303 Upper*	22-14413
4		22-14325	22-14345	22-14414	22-14416
5	22-14303	22-14326	22-14346	22-14417	22-14418
6		22-14328	22-14347	22-14419	
7		22-14329	22-14348		
8	22-14304	22-14330	22-14349		
9			22-14350		
10			22-14351 30-14304*		
10.7*			30-14304*		
11	22-14305	22-14352			
12		22-14353			
13		22-14354			
14	22-14306	22-14355			
15		22-14356			
16		22-14357			
17			22-14358		





COAXIAL CABLE CONNECTORS

Coaxial cable assemblies on Convair jet airliners are used for connecting the numerous antennas to their respective equipment. Each cable assembly is a precisely fabricated unit of exact length with precision-built connectors at each end. Manufacture of the coaxial cable from which these assemblies are made has reached a high degree of perfection, as have the connectors used at the ends of the assemblies.

Where service replacement has been found necessary, the difficulties have most generally been traced to the area of the connectors; occasionally, however, physical damage to the outer metallic shield of the cable has been responsible.

Although some coaxial connectors used for general commercial installations are of fairly rugged construction, those for aircraft electronic installations are more finely constructed, and require more care in handling. Many of the contacts are silver-plated — some are even gold-plated — to attain a high degree of conductivity.

Coaxial cables consist, generally, of a single wire or strand of fine wires in the center of an insulating material (such as Nylon or Teflon), and an outer metallic shield, or shields.

A solid shield, such as aluminum or copper tubing, is used where very complete shielding against stray electrical interference may be required, or where rigidity of the installation is desirable.

Single metallic mesh-shielded coaxial cable is used where the installation is not critical; dual mesh is used where a higher degree of shielding, approaching solid tube performance, is required. The mesh-shielded coaxial cable facilitates installation. It is clamped at frequent intervals to prevent flexing.

It is important that the conductor and outer shield be joined at the connectors with a high degree of concentricity, and that the dielectric insulating material maintain this concentricity.

It is also important that the central conductor establish a high degree of conductivity at the connector and that the outer shield be well bonded at the connector. Care should be exercised both in detaching and reinstalling coaxial cable during maintenance operations.

The manufacturers of the connectors provide full instructions for attaining the best in assembly operations. These include:

1. *Careful removal* of any outer protective coating, down to the shielding.
2. *Precise right angle trimming* of the shield (tube or mesh) to facilitate good bonding when assembled into the connectors. This includes removal of any burrs from the tube shield, to avoid damaging the underlying insulation.
3. *Care in removing insulation* to expose the conductor, prior to soldering to the plug or mating socket. Slight nicks at this stage can cause subsequent cracking or breaking of the conductor wire or strands under conditions of vibration.
4. *Careful control of soldering heat* to preclude damage to the insulation, plus removal of all soldering flux.

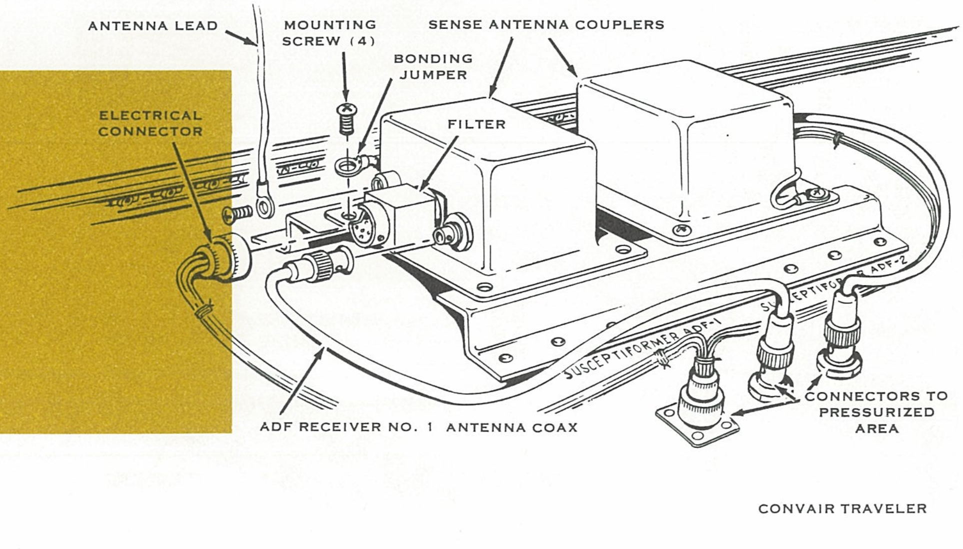
Manufacturing tolerances require that the concentricity between the conductor and its shield shall vary less than 10 percent. Sharp bending of any coaxial cable should be avoided because it may cause the alignment to go beyond the 10 percent. Variations of this sort upset the established impedance (ac resistance) of the cable, and can cause unbalance of circuits in which the coaxial cable is used. Fabrication of shielded coaxial cable into assemblies requires particular care to avoid unnecessary bending; where required, the bends are formed over special bending blocks.

Each tube clad cable shipment, when received at GD|Convair, is inspected without uncoiling the cable. Kinks, circular cuts, or dents are cause for rejection. Longitudinal cuts or scratches may not exceed 0.003 in depth. Test for dielectric breakdown of the new cable is made at 4000 volts ac, and for shorts and leakage at 600 volts dc.

Cables received in large coils are to be stored flat in the original container. Only the fabrication department is permitted to straighten or bend the cable as required. Repeated bending is not permitted.

Whenever coaxial cable is to be stored, it is recommended that the cable ends be sealed against moisture.

typical antenna and connector installation

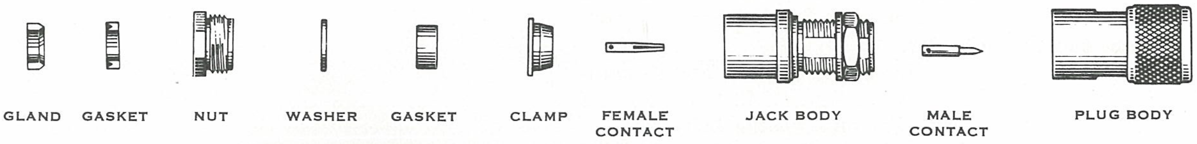


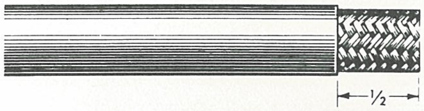
Moisture, working its way into the cable ends, could upset the normal impedance characteristics of the cable.

At General Dynamics|Convair, extreme care is exercised in stripping the insulation that separates conductive wire and shielding. When the tube or mesh shield has been removed to expose the insulation, the insulation is lightly cut a slight amount around the outside only. A Nylon cord is then wrapped around this cut and used to complete the separation. This precludes the nicking of the inner conductor.

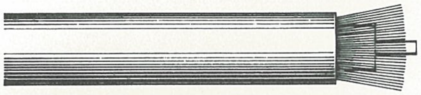
Coaxial cable assemblies, as used in the Convair antenna systems, are not just conductive wires — they are precision-built components of the electronic systems. They should be treated as parts of a delicate instrument — that is what they are.

typical cable connector assembly instructions

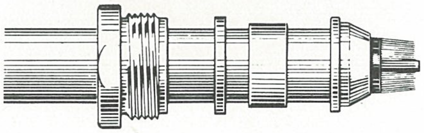




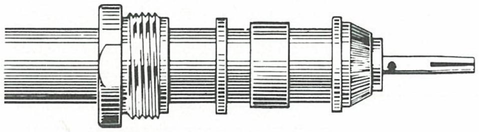
Remove 1/2 inch of vinyl jacket. When using double-shielded cable, remove 9/16 inch.



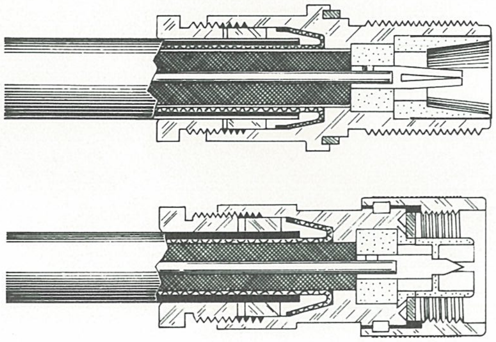
Comb out copper braid. Cut off dielectric 7/32 inch from end. Tin the center conductor.



Taper braid as shown. Slide nut, washer, and gasket over the vinyl jacket. Slide clamp over braid with internal shoulder of clamp flush against end of vinyl jacket. When assembling connectors with gland, be sure that knife edge is toward end of cable, and that groove in gasket is toward the gland.



Smooth braid back over clamp, and trim. Soft-solder the contact to the center conductor. Avoid use of excessive heat and solder. See that end of dielectric is clean. Contact must be flush against dielectric. Outside of contact must be free of solder.



Carefully slide body into place so that the contact enters hole in insulator. Face of dielectric must be flush against the insulator. Slide the completed assembly into the body by pushing the nut. When nut is in place, tighten with wrenches. When tightened sufficiently, the knife edge should cut the gasket in half in those connectors having a gland.

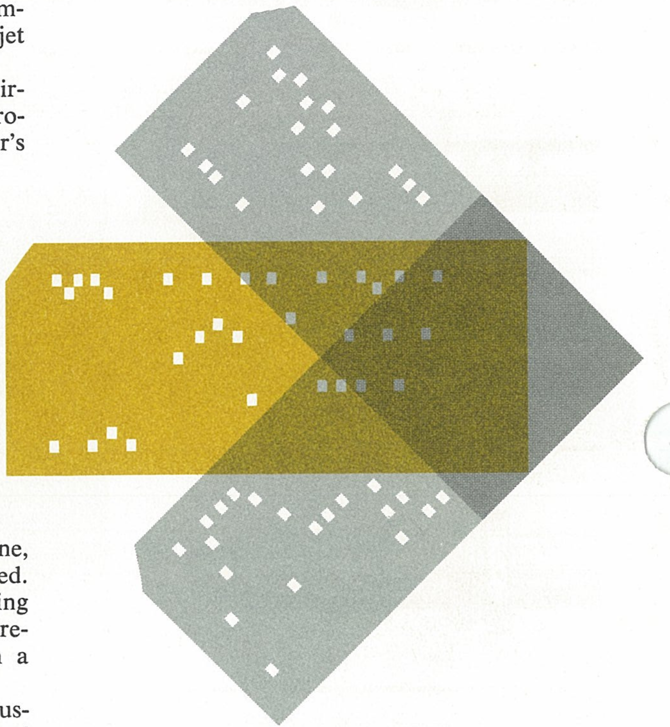
6 40

Whether it's a request for a special bracket or a wing center section, Convair's Service Parts Department can fill the order.

A thorough knowledge of the airplane and its components — from the Convair-Liner 240 to the 990 jet airliner — assures efficient on-schedule deliveries.

Men trained in the supply and support needs of aircraft in the field are on hand 24 hours a day to provide rapid service in processing the needs of Convair's commercial customers.

PARTS



When a spare is needed for a grounded airplane, the part is shipped the same day the order is received.

Adequate parts stocking and dependable packaging and shipping are handled from Convair's unified warehousing facilities — all through negotiations with a single office.

Convair's Service Parts section monitors all customer procurement and supply functions associated with spare parts, ground support equipment and modification kits. Delivery of these items to Convair's customers never stops. There are parts to spare whenever they are needed — next week, next month, ten years from now.

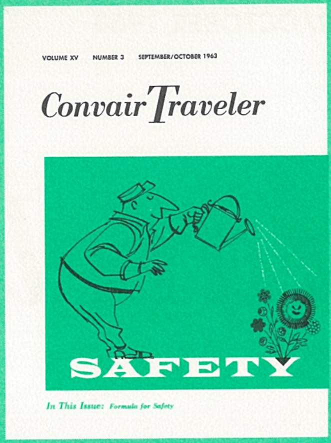
GENERAL DYNAMICS | CONVAIR

VOLUME XV NUMBER 3 SEPTEMBER/OCTOBER 1963

Convair Traveler

WHATEVER A MAN SOWETH, THAT SHALL HE ALSO REAP . .
WHATEVER A MAN SOWETH, THAT SHALL HE ALSO
WHATEVER A MAN SOWETH, THAT SHAL
WHATEVER A MAN SOWETH, TH
SAFETY

In This Issue: **Formula for Safety**



VOLUME XV NUMBER 3 SEPTEMBER/OCTOBER 1963

Convair Traveler

SAFETY

In This Issue: Formula for Safety

OUR COVER

H. L. Mencken said, "Nothing can come out of an artist that is not in the man," and Saint-Gaudens added, "What garlic is to salad, insanity is to art. "Our readers who like a touch of garlic will enjoy Willis Goldsmith's art in this issue.

Convair Traveler

VOLUME XV NUMBER 3 SEPTEMBER/OCTOBER

MANAGER, CUSTOMER SERVICE — **O. W. HARPER**
CHIEF ENGINEERING SERVICE — **L. J. BORDELON**
CHIEF, FIELD SERVICE — **R. W. SOMMERS**
CHIEF, SERVICE PARTS — **J. DOIG**
CHIEF, TECHNICAL PUBLICATIONS — **H. R. KENNEDY**
EDITOR — **GERTRUDE S. HUNTER**

IN THIS ISSUE

FORMULA FOR SAFETY

Gertrude M. Hunter

Formula for Safety is in line with the proclamation of N. E. Halaby, F.A.A. Administrator, in proclaiming the year 1963 as "Maintenance Year," and with establishment of the Aviation Mechanic Safety Awards Program. Although 1963 will soon give way to another "proclaimed" year, safety in aircraft maintenance will be just as important in 1964 —and on.

A digest of operation and service published monthly by the Technical Publications Section of GD|Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics|Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

COPYRIGHT 1963

GENERAL DYNAMICS | CONVAIR

FORMULA FOR SAFETY

Early and provident fear is the mother of safety — BURKE

SAFETY IN AIRCRAFT MAINTENANCE and operation is dependent to a great extent on servicing and maintenance personnel—*their alertness, respect for the task,* and *know-how.* Aircraft in itself does not present a hazardous occupation, but "care-less" maintenance can contribute to damage to aircraft and equipment, and injury to maintenance personnel, crew, and passengers.

Some aircraft accidents are listed as "cause undetermined." It is quite possible that a few of them could have been the result of care-less maintenance. *Don't become the "most probable cause."*

Thoughtless handling of ground equipment and tools, and hasty maintenance of complicated aircraft systems often result in increased man-hours and maintenance costs. Safety is sacrificed when the wrong equipment is used for a specific job, or the prescribed equipment is used incorrectly.

Shortcuts as a general rule present a hazard—either to personnel or to equipment. A shortcut usually indicates that someone wants to get the job done quickly, and he will side-step a safety rule to save a few seconds.

Most accidents take place in areas of every day familiarity—fueling, general maintenance, electrical repairs. The mechanic becomes complacent and overconfident when performing the same routine day after day; and this overconfidence and subsequent inattention, or carelessness, can turn the most routine duty into a hazardous operation. Most accidents to personnel and equipment are due to carelessness, not to ignorance or inexperience. If a mechanic fails to keep the hazards and the importance of his job in mind, the mistake he makes can have serious consequences.

It is true that some accidents and injuries are the result of component or equipment failure—towbars fail, high-pressure pneumatic lines give way, hydraulic lines burst, and brakes may slip—but, any form of accident emphasizes the need for diligence, knowledge of the hazards, and appropriate precautions.

Procedures or work operations that are contrary to those established by the manuals or by the operating airline should not be attempted without specific approval of the foreman or supervisor. A number of "avoidable" accidents can thus be reduced.

On this and the following pages are discussed some of the areas in which accidents may occur and where injuries can happen, and how aircraft and crew can be jeopardized.

Engines

The cautious seldom err. — CONFUCIOUS

The law of self-preservation is man's greatest natural law: but, there are many who have tried to break this law by attempting self destruction. Some have succeeded; others have lived to tell about the experience from their hospital beds.

Severe injury or death can result from being sucked into the intake of an operating jet engine. Even though the dangers at or near the operating engine intakes are known and are constantly stressed—in bulletins, manuals, special practices, magazines—personnel become complacent, forget the most basic rules, and walk absent-mindedly into the danger area.

Don't become F.O.D. (Foreign Object Damage) and make your impact on a compressor. Stay alert and keep the following precautions in mind.

Only those persons absolutely necessary to the operation of the jet engine should be permitted in the vicinity of the aircraft when engines are being operated.

Remember—there is no visible indication of the in-rushing air at the jet engine intake.

The danger area in front of a CJ805 engine is a half circle, approximately 25 feet in front of and on each side of the engine, and slightly to the rear of the intake. For safety's sake, always keep a distance of several feet outboard from the wing tip, and walk —never run—parallel to the fuselage. These areas are to be respected if personal safety is to be considerd.

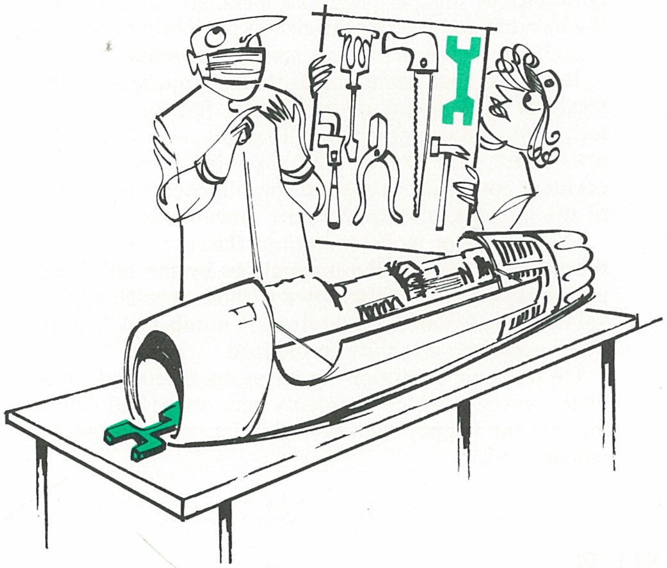
Immediately aft of the tailpipe, the temperature is 1000° F with a high exhaust velocity: It goes without saying that personnel should not be in this area or within 200 feet of the tailpipe when engines are *to be* operated. Because of the tremendous force of the blast, there is little possibility of personnel entering the area when engines *are being* operated.

The immediate intake and exhaust area should be avoided for at least 15 minutes after engine shutdown, because fuel or oil draining onto hot engine parts after engine shutdown could ignite and cause fire and/or explosion.

Of all noises,
I think music the least disagreeable. — JOHNSON

Fuel spills, grease, and oil spots should be wiped up when they happen, with static free cloths or commercial preparations. A grease or oil spot could cause personnel to slip and fall into a danger area.

Jet engine noise is a problem because it can permanently impair hearing. The deafening sound of a full-powered jet engine requires the use of ear plugs, ear muffs, and helmets for varying degrees of sound attenuation and hearing protection. Within 100 feet, all personnel should be required to wear properly fitted ear plugs, ear muffs, and a helmet; at distances of 100 to 200 feet, ear plugs or ear muffs should be worn by all personnel if the engine is running above idle power. The use of properly fitted ear plugs or muffs will reduce the effective sound pressure level by approximately 20 decibels; wearing a helmet will lower the sound level an additional amount.



He's got 'em on the list,
and they'll none of 'em be missed. — GILBERT

The primary cause for premature engine removal is foreign object damage. Contrary to popular belief that foreign objects are picked up on runways and taxiways, the greatest incidence of foreign object damage is maintenance-generated.

The incidence of F.O.D. can be decidedly reduced if prescribed maintenance practices and good housekeeping procedures are observed. Preventive maintenance, rather than corrective maintenance, enters the picture here. Most engine failures as a result of F.O.D. reveal such items as wrenches, screwdrivers, pliers. This type F.O.D. can be attributed to careless maintenance practices, and a lack of inspection for foreign objects prior to engine run-up.

Just as a surgical team counts all sponges and instruments before an operation, and checks the count before the final suturing, so should all tools be counted before a mechanic enters the engine intake duct, and counted again after completion of the maintenance job, so as to preclude the possibility of leaving something behind, with subsequent engine damage, and a possible succession of more serious consequences.

Be sure your tailor is a man of sense. — HOLMES

The engine inlet duct should not be used as a receptacle for holding tools, or even for such small items as washers, lockwire, and screws, when working adjacent to the engine intakes.

A special one-piece zippered uniform with zippered pockets—no buttons—should be worn when performing maintenance inside the engine intake duct.

No loose clothing—caps, scarves—should be worn in the area of an operating jet engine. All articles of clothing should be "nailed down" so that the suction cannot pull it loose and into the engine.

A clean work area should be maintained. All metal objects on the ground and on workstands in the engine-run area should be picked up and disposed of. Even soft articles, such as caps and rags, when ingested into the engine, can constitute a threat to the safety of the aircraft.

Exposure to F.O.D. can be reduced if maintenance personnel observe the foregoing rules and stay alert.

Ground Handling Equipment and Operation

Error is not a fault of our knowledge, but a mistake of our judgment. — LOCKE

Most ground accidents and incidents are a result of improper or careless use of tools and wheeled equipment, and improper ground maneuvering of the aircraft. Misjudging a vehicle during ground maneuvering could result in serious damage to the aircraft. Aside from gouges and other external damage, serious internal damage could extend to wiring, tubing or mechanisms positioned behind the affected areas. A skin patching job alone could place an airplane out of service for hours or even days, resulting in costly delays.

During towing and taxiing maneuvers, it should be kept in mind that the swept wings of the Convair jet airliner "grow" whenever the aircraft makes a turn.

With conventional straight wing aircraft, the wing tip can be expected to follow a radius from the turning center point. The distance such a wing tip reaches out is equal to the wingspan—no clearance problems.

On the other hand, with the swept wings, the wing tip also follows the radius, but since the wing tip is aft, the distance from the wing tip to the turning point is greater than the wing span. Thus, whenever a turn is made, the wing tip will swing in an arc that is greater than the wing span. In the case of the Convair 880 and 990, this "growth" or extra "reach" added to the wing span, can be as much as five feet.

Unless the airplane is to be towed or taxied in a straight line, or with turns less than 40°, the steering arm torque links should be disconnected. This permits the nose wheel to swivel 360°. The largest possible towing radius should be used; turning at angles greater than 50° will result in scuffing of main landing gear tires.

With torque links connected, damage can occur if turn rates exceed 10° per second. At higher rates of turn, the resistance offered by the steering cylinder may result in overloading of the torque links and possible damage.

With torque links disconnected, it is imperative that no attempt be made to steer the aircraft from the cockpit. Cockpit occupants must not handle the nose steering wheel in any manner until after the tow bar has been disconnected and turning of the wheel is requested from the ground.

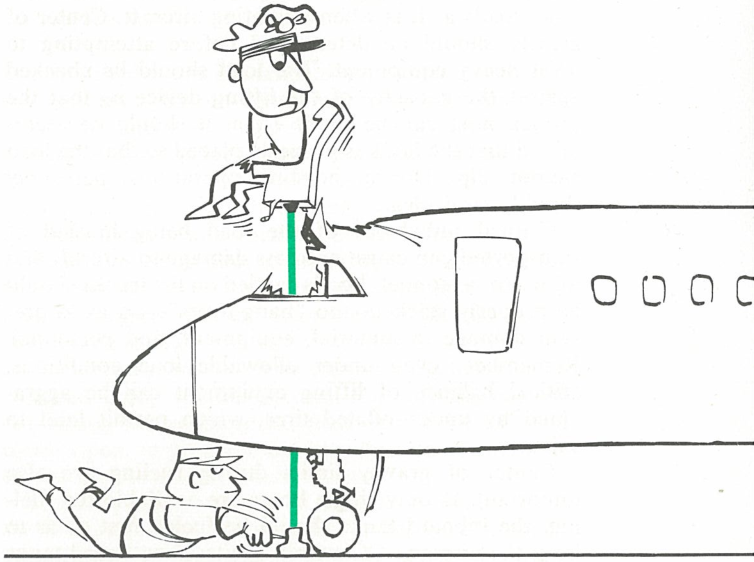
The maximum towing limits specified in the Maintenance Manual should be observed. Wheel chocks should always be available in case of emergency stops or in case tractor brakes fail.

When taxiing the aircraft, the additional precautions listed under ENGINES on pages 3 & 4 should be observed.

Improper positioning of a jack under designated jacking points—whether jacking the entire airplane or just a landing gear—could cause extensive damage to the aircraft structure and injury to personnel. Wing and fuselage jacking points on Convair jet airliners require a fitting to adapt them to the jacks. The fitting is interchangeable between the three jack points and between Convair 880/880M/990 aircraft. The load factors and jacking limitations noted in the applicable Maintenance Manuals should be observed when jacking the airframe or landing gear. For example: a main landing truck that is jacked too high at one end in an effort to place a jack under the center jack point places the truck at an excessive angle, contributing to possible damage to the bogie beam.

Before lowering jacks, it should be determined that all equipment and stands under aircraft are removed.

Jars or shocks from rough handling or from incorrect attachment of ground handling equipment could result in extensive damage to aircraft.

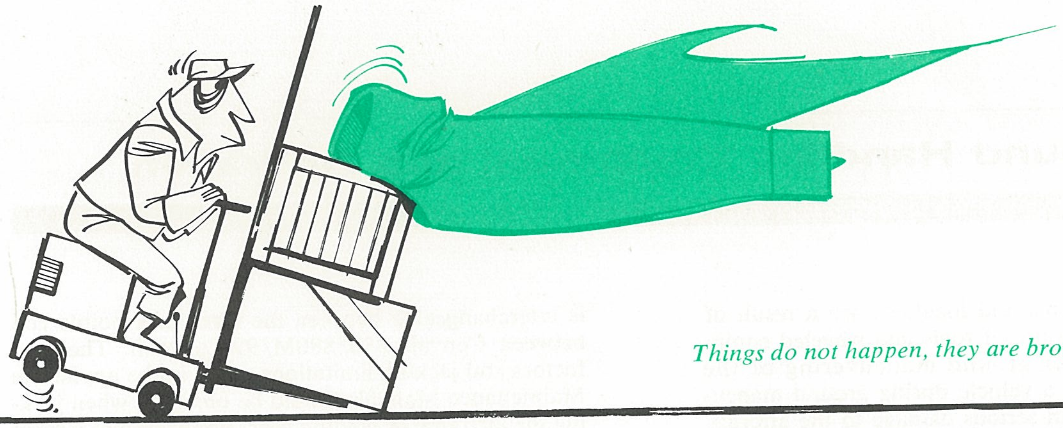


What we anticipate seldom occurs;
what we least expect generally happens. — DISRAELI

There are two kinds of damage—visible and concealed. Visible damage is in the form of scratches, dents, abrasions, cracks. Material so damaged often requires repair or scrapping; careless handling around painted surfaces may necessitate repainting.

Concealed damage consists of internal damage to mechanisms, system components, etc. There are some types of cracks that are not visible to the naked eye. Only after many hours of flight time do they begin to show. Sometimes this is too late to avoid failure of the unit or damage to the aircraft.

Inadvertently bumping a gear part with ground equipment, for example, could result in an operation that is costly, both in man-hours and dollars. Whenever there is visible indication of high stress or impact, or if it is known that a gear part has been subjected to heavy impact or localized stress, the part should be removed and thoroughly inspected by all available



Things do not happen, they are brought about.— HAYS

methods. "Hiding" such damage could result in loss of aircraft and lives, since a crack in the high-strength, high-heat-treat steels of the landing gear could cause sudden failure of the gear after a period of service. Even the slightest damage to the gear should be brought to the attention of the man in charge, since a dent or a severe jolt may be all that is needed to initiate failure.

Determining center of gravity limits is just as important when using ground equipment and when handling loads as it is when operating aircraft. Center of gravity should be determined before attempting to hoist heavy equipment. The load should be checked against the capacity of the lifting device so that the proper sling can be used. Then, it should be ascertained that the hook is properly placed so that the load cannot slip. During hoisting operations, personnel should stand clear.

Critical unbalance of the load being hoisted or transported can cause needless damage to aircraft and injury to personnel. Loads carried on lift trucks should be properly stacked—no "hang-overs"—so as to prevent damage to material, equipment, and personnel. Remember: even under allowable load conditions, critical balance of lifting equipment can be aggravated by under-inflated tires, which permit load to shift.

Center of gravity limits during fueling are also important. If only single hoses are available for fueling, the inboard tanks should be fueled first so as to keep the airplane CG within limits; if outboard tanks are filled first, it could cause the nose landing gear to leave the ground. During fueling, the airplane will tend to settle from the weight of the fuel. Thus, all work stands, ladders, etc, should be removed or cleared from the area to preclude damage to equipment and airframe.

Removal of work stands before making operational checks of control surfaces is also important. The flaps have been subjected to unnecessary damage because stands were not removed before making operational checks of this surface.

Besides careful handling, ground equipment and tools require regular inspection and maintenance to keep them in top condition, and safe for use. For example: a defective ground power unit, having a short circuit in the electrical system, or an arc across a terminal, could spark or backfire, igniting flammable vapors during fueling operations; a Reed and Prince screwdriver, with the point ground off to make it usable for removing Phillips head screws, can burr the slots and render the screw unsuitable for further use, and may necessitate drilling out the screw.

Special tools and equipment should be used only for the purpose for which they were intended. While it is vitally important to have the proper equipment and tools to do a specific job, the proper use of these tools is equally important, if damage to the aircraft or injury to personnel is to be prevented. Tools that are misused lead to increased maintenance man-hours, damage to aircraft, and, sometimes, serious or fatal injury to personnel.

All it takes is a little common sense and adherence to established rules. Granted, it may be possible to use an unauthorized item of equipment to do the prescribed job, or, like Murphy, to use the prescribed equipment incorrectly, but when you do, protection is sacrificed, and you lay yourself wide open for problems. Remember—the right way is the best way—it was planned that way.

Systems Servicing

He is safe from danger who is on guard even when safe. — PUBLILIUS

The men who fuel aircraft are subjected to many hazards, and work under difficult conditions, making their work critical to safe operation. The precautions in Section 12 of the Maintenance Manual should be strictly adhered to. The following additional precautions will ensure safe fueling practices.

When fueling the aircraft, a cross-check should be made of the number of gallons put aboard. The tank truck flowmeter indicates the amount of fuel added—not the total amount on board. A cross-check should be made with the fuel capacitance system, truck flowmeter and dripsticks.

An airplane should not be fueled when it is within 120 feet downstream of the tailpipe of a jet airplane that has an engine running. *Jet exhaust is dangerous.* If a jet airplane moves into the fueling area, fueling operations should be stopped immediately, and the tank truck removed from the area.

The airplane and fuel truck should be grounded as specified in Section 12-1 of the Maintenance Manual. It should be remembered that 1) a drag chain from a fuel truck is not a suitable ground — fuel trucks must be connected to ground posts; 2) a conductive type fuel hose is not a suitable ground; and 3) aircraft and truck should be grounded from an unpainted metal part.

Any spill, regardless of size, is a hazard, and spills spreading over six feet in any direction constitute an extreme hazard.

In the case of large spills, the airport emergency fire crew should be called at once. Motorized equipment operating outside the "spill" area should be moved away or shut down as quickly as possible. The throttle should be closed and the engine shut down by choking the carburetor, because shutting off the engine ignition at full throttle may cause backfires.

If the fueling equipment is operating inside the spill area, *leave it alone*. The fire department will eliminate the danger with special equipment.

Large spills should be covered with foam, and then washed away or allowed to evaporate completely. When washing spills, the area should be flooded liberally to prevent gasoline vapor from forming in storm drains. Carbon tetrachloride should not be used. It is only partially effective, and it may become a toxic hazard.

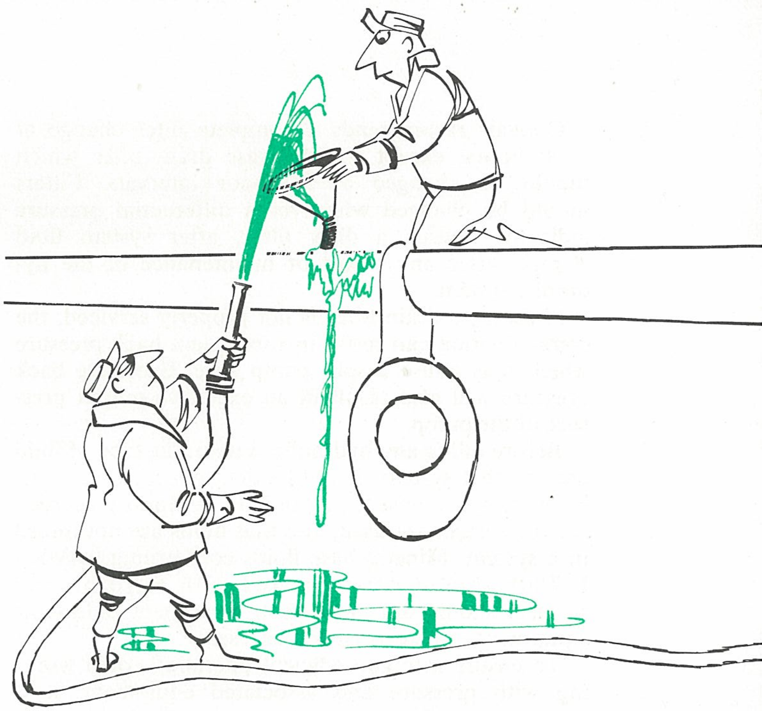
Clothing on which aviation gasoline or jet fuel has been spilled should be removed immediately. Neglect of a sleeve or cuff that has been soaked in fuel, or in any inflammable liquid, can lead to painful burns.

Water in jet fuel is a constant problem. Because of the greater density of turbine fuels, water will not settle out as rapidly as it does in aviation gasoline. Settling time for water in turbine fuels is approximately four times that of water in aviation gasoline. Conscientious and periodic draining of sumps will eliminate much of the free water. The drained residue requires frequent analysis to determine amount of water in the system, and to detect any indication of impending failure of fuel system components. The January/February 1963 issue of the Traveler gives detailed information on the control and prevention of water in jet fuels.

Contaminated hydraulic systems can result in partial or complete failure of a system or of one or more of its components. Contaminant-free fluid delivery is dependent on periodic inspection of filters, sumps, and associated handling equipment. Because of the close tolerance between working surfaces of components in aircraft hydraulic systems, even small quantities of very fine contaminants could cause binding, scoring, and wear between these working surfaces. Therefore, filters must be carefully maintained so that they do a thorough cleaning job.

Present Convair jet airliners utilize two types of hydraulic filters—wire mesh and paper (Micronite). The wire mesh type is used in the high-pressure system (3000 psi), whereas the Micronite type is used in the case drain and low-pressure sides of the hydraulic system.

Micronite elements are to be disposed of when they become contaminated; therefore, a periodic inspection at prescribed times is mandatory to keep a hydraulic system clean. Before removing a filter or filter element, the entire unit should be wiped clean with a lintless cloth or paper to prevent contamination. Fluid lines should be capped immediately and the filter element placed in a polyethylene bag to protect it against physical damage and further contamination.


Chance is a word void of sense. — VOLTAIRE

Even though a filter element appears to be clean to the unaided eye, it may be partially or even completely clogged. A used filter element should not be installed because it "looks" clean. Only new filter elements or those *known* to be clean should be installed.

When ready for installation, the polyethylene bag containing the replacement filter should be cut—not torn—open, to preclude the introduction of small bits of the bag to the hydraulic system.

If wear particles appear in the filter bowl, it may be the first indication of impending pump or component breakdown. If contamination is found in the pump case drain filter, the hyraulic system should be flushed.

Dirt is not dirt, but only
something in the wrong place. — LORD PALMERSTON

Convair recommends a complete filter change at 3000 hours, except for the case drain filter which should be changed at 350-hour intervals. Filters should be changed whenever a differential pressure indicator reveals a dirty filter, after system fluid change, after any repair or maintenance of the hydraulic system.

If the case drain filter is not properly serviced, the contamination can result in subsequent back pressure which may cause a split pump case. Excessive back pressure will also result in an excessive output pressure of the pump.

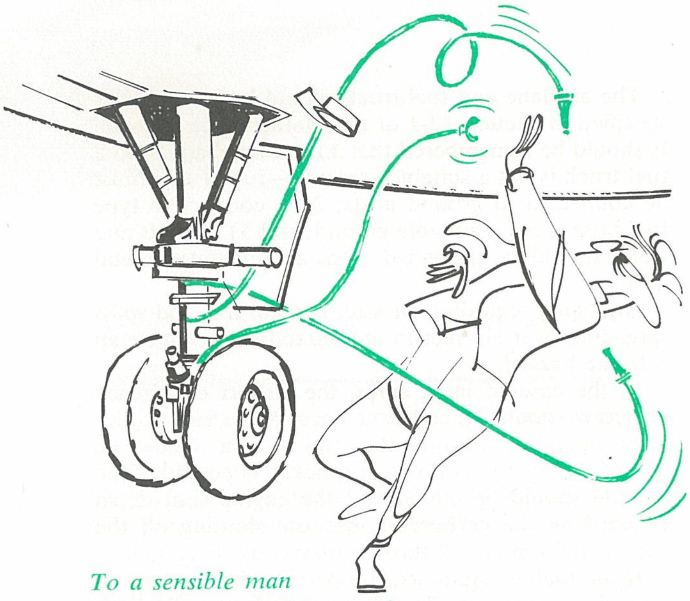
Before filling any hydraulic system, the type of fluid used in that system should be determined. Care must be exercised to ensure that only those fluids placarded for the system are used, and that fluids are not mixed in a system. Mineral base fluids conforming to MIL-L-7808 should not be mixed with Skydrol, and Skydrol should not be used in equipment unless the equipment is placarded for its use.

To ensure safe and efficient operation when working with pressure and associated equipment, it is important to be constantly aware of the hazards involved.

High-pressure air lines and flexible hoses require care in handling. All lines should be securely attached to a solid support, and flexible hoses should be securely anchored or "sandbagged" to prevent whipping in the event of a line rupture or failure of a connection.

Before working on any high-pressure line, the system should be depressurized. If an external hydraulic power unit is connected, it should be shut off before disconnecting any hydraulic system component, and a warning placard placed on the control panel. Better still is to disconnect the unit from the airplane.

When connecting a source of dry compressed air or nitrogen, the connection must be secure. When removing valve cap or when opening the valve, the valve body should be firmly held with a wrench. A loosened valve assembly could be blown out by internal pressure, causing serious or fatal injury to personnel.



To a sensible man
there is no such thing as chance. — TIECK

When servicing any high-pressure units such as landing gear struts, truck positioners, brake pressure modulators, etc, loosen the hex swivel nut on the air filler valve a maximum of ¼ turn, and allow air to escape slowly. *Do not loosen or remove valve body until air pressure has been bled off; otherwise, the plug can become a dangerous missile.*

Struts should be inflated in accordance with the instruction placard in each wheel well. An improperly inflated nose strut can cause binding during a turn; improperly inflated main gear struts can result in bottoming of the strut during the landing impact with subsequent damage to gear components and airframe.

Electrical Maintenance

A fool must now and then be right, by chance. — COWPER

Every person who works near electrical equipment should exercise extreme care, and be familiar with the hazards involved. Any circuit may be "hot"; it should never be assumed otherwise until a check has been made.

Failure to deenergize circuits before performing maintenance operations is one of the most common causes of shock and fire—and, it often leads to damage to expensive equipment.

Wiring or electrical equipment should never be removed from, or installed on, a "hot" circuit. This includes removal and installation of junction box covers or fuses, when power is on. Positive means should be taken to ensure that the circuit involved is deenergized.

If it is not possible to deenergize the entire airplane electrical system before performing maintenance on an electrical circuit, the circuit involved in the maintenance operation should be isolated by pulling the circuit breaker. *If fuses are to be removed, power must be removed first.* Every precaution should be taken to prevent accidental contact of control cable, tools, metal parts, and fuel lines. Accidental cross-contact between electrical components and metal parts whenever flammable vapors are present can have serious consequences. A "dummy" plug installed in the airplane ground receptacle will prevent inadvertent connection of ground power units.

If a fuse blows or a circuit breaker trips, the cause should be determined before replacing the fuse or resetting the breaker. If a wiring system has been modified, it should be checked against the wiring diagram, and an operational check made before releasing the aircraft for service. Wiring errors can cause damage to equipment and injury to personnel.

When soldering an electrical connection, use solder sparingly. An excess of solder, or solder inadvertently dropped in the wrong place, can short out a circuit.

The AC power distribution panel should not be opened when the battery is on, when engines are running, or with external power connected to the airplane.

When checking circuit continuity of the fire extinguishing system, cartridge and bonnet must be properly installed in the airplane. This cartridge is similar to a pistol cartridge and could cause injury or death if accidentally fired.

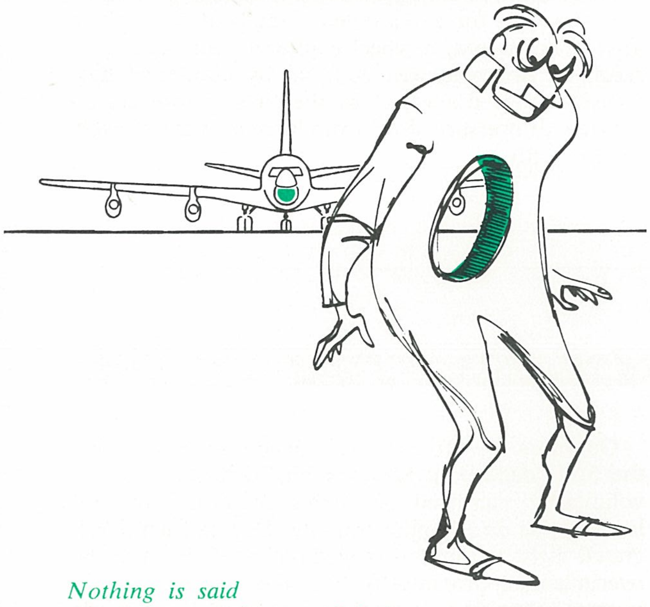
New or repaired equipment should be thoroughly bench-checked before installation on the airplane, to guard against "shorts." This is extremely important where radar or radio components are concerned. These components should be repaired and tested at locations away from the airplane, and flammable liquids should not be handled within 100 ft of radio or radar antennas whenever either system is in operation. The use of radar in the vicinity of a fueling operation can have startling results—fuel vapors can ignite with explosive force.

In a test of radar equipment to determine the range of dangerous effects, a radar beam was directed at a variety of objects with the following consequences:

- Steel wool was ignited at a distance of 45 feet.
- A mixture of aluminum chips and gasoline vapor and air exploded at a distance of 250 feet.
- Hand tools became heated and gave off sparks at various distances from the radar source.

The foregoing test results emphasize the need for caution near operating radar or high-frequency radio transmitters.

From these tests and from medical reports on radiation, it is known that excessive amounts of radiation can cause biological damage to the human body, but the body receives a warning signal in the form of heat generated on exposed areas of the skin. It behooves the exposed person to quickly move out of the vicinity of the beam or microwaves.



Nothing is said
which has not been said before.— TERENCE

Because of the long-range electrical arcing effect of radar, good maintenance and housekeeping are essential to safety. This includes the removal of trash, metal scraps, and oil rags, and the education of people in the hazards of radar exposure.

Aircraft ground power generators and rectifiers should not be located down-wind or near the fueling points, and should not be connected or disconnected, or stopped or started during fueling operations.

Electrical systems of ground power units should be kept in first-class condition.

Servicing personnel should be kept especially alert when working with electric power cables used on motor generator units and tow trucks. Short circuits, arcing across terminals, sparks or backfire flame from the exhaust can ignite flammable vapors. A defective contactor, or a cable with its insulation worn or cut through to the conductor should not be used. It is a good point never to handle the cable when it is "hot" and always to push the button on the generator to OFF and wait for the indicator light to go out before disconnecting the cable from the airplane. Particular care should be exercised during wet weather.

When removing batteries from the airplane, care should be used. If terminal prongs are allowed to touch nearby metal, the resultant "shorts" will cause sparking and arcing. If flammable vapors are present, fire and explosion may follow.

Batteries should not be connected while another man is working on a part of the airplane circuitry. Every precaution should be taken to see that maintenance personnel are informed when the battery is to be connected.

Extreme care should be used when working around the tops of the batteries. Severe sparking could result if insulated tools are dropped on the cell terminals.

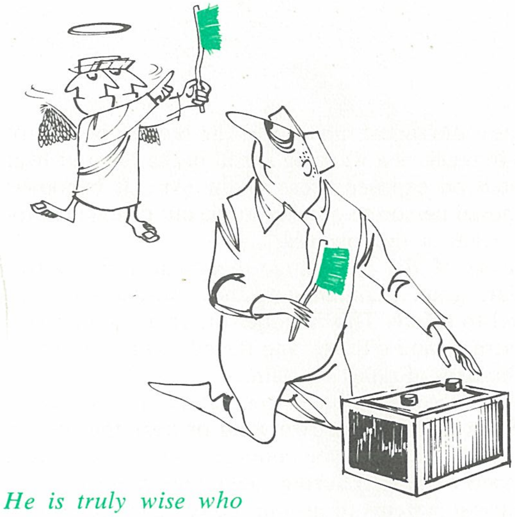
Potassium hydroxide is highly corrosive. Rubber gloves, aprons, and face shields should be worn at all times when handling this solution. If any fluid is spilled on hands, clothing, or other materials, the area should be flooded immediately with cold water. A boric acid solution, vinegar, or fruit juice will neutralize the spilled potassium hydroxide. A physician should be consulted immediately if solution comes in contact with the eyes.

Acid-bearing tools should not be used on nickel cadmium batteries because use of these tools could contaminate the electrolyte. Acid type and nickel cadmium batteries should not be serviced or stored in the same area.

Vent plugs should be closed before cleaning the battery. *Do not use a wire brush for cleaning.*

Two men should be present whenever work is being performed on "hot" circuits, especially in the area of flammable fluid lines; and adequate fire fighting equipment should be available for immediate use.

All electrical maintenance personnel should be familiar with rescue techniques. An electrical shock



He is truly wise who gains wisdom from another's mishap. — PUBLILIUS

victim can usually be saved if the proper steps are taken—and without delay.

The connection between the victim and the power source should be broken immediately. If power cannot be turned off immediately, a non-conducting object, such as a board, should be used to remove the victim from the voltage source without danger to the second person. As soon as the victim can be touched, artificial respiration should be administered. Even though the victim may appear dead, artificial respiration should be continued. Sometimes several hours elapse before a victim responds.

It is much simpler and safer to know the proper procedures for working on electrical equipment than it is for working on an electrical shock victim—he could be you.

Brakes

Knowledge is a treasure, but practice is the key to it. — FULLER

Brakes are a device for converting kinetic energy into heat. With a brake of given size and shape, only a certain amount of kinetic energy can be converted into heat before the temperature of the brake becomes so high that the parts get soft and fail. This temperature is determined largely by the rate of kinetic energy absorption by the brake, compared to the rate of heat dissipation to the surrounding air and to wheels and tires. On a rejected takeoff (RTO), for example, energy is absorbed many times faster than on normal landings and heat thus generated can cause brake damage. On normal landings—gross weights being equal—energy is absorbed more slowly and the temperature rise is less.

Overheated brakes can be dangerous. Special knowledge plays an important part in the safe handling of overheated or burning brakes or wheels. In every case where an overheated brake condition exists, only those personnel qualified to deal with the situation are to be in the area and they are to maintain a safe distance.

A dry chemical agent is recommended for use on all wheel and brake fires. This agent absorbs heat rapidly without chilling.

If dry chemicals are not available, in the case of a brake fire, most firemen would stand by for a minute or two with equipment at the ready to see if the fire would burn itself out. A wheel explosion from quenching or rapid cooling can be more dangerous than small brake fires.

If the fire is severe enough that it must be extinguished, the agents recommended are fine spray, foam, and water, in that order. Spray or foam should be used, as lightly as possible, by a man standing well clear of the gear — 20 feet or more, forward or aft and never broadside to it. CO_2 is a last resort; the danger of explosion is worse, and using it requires standing too close.

After a fire is extinguished, it is advisable to evacuate the area for a reasonable length of time. Even after a fire is out, a wheel explosion can occur as a result of tire pressures built up by continued heat transfer from the wheel to the tires. However, increased air pressure alone from mere heat is not likely to blow a tire.

Tires

Facts do not cease to exist because they are ignored. — HUXLEY

Types VII and VIII tires, used on Convair jet airliners are designed for optimum wear, consistent with a reasonable non-injurious heat buildup at 32% deflection. In practice, heat causes an increase in tire pressure, reducing the percentage of deflection. This is desirable and explains why tire pressures should be adjusted only when tires are cool.

Optimum tire life can be obtained only by ensuring the 32% deflection; however, this deflection can be voluntarily sacrificed on flights requiring frequent landings, as during pilot training. During such accelerated flight training, it is recommended that tires be overinflated approximately 20% above normal. Under normal operating conditions, overinflation would strain the tire, increasing skidding tendencies, and subject the center tread to excessive wear.

Underinflation, on the other hand, would result in flexing of the carcass, building up heat in the tires. In time, this heat buildup would break down the sidewalls.

Under normal operation, sidewall deflection can be controlled within normal tolerances by varying inflation pressures for loading within the rating of the tires. Some deflection is desirable to absorb shock loads—it permits the tire to flatten somewhat, thus providing a larger bearing area and distributing wear evenly across the tread.

To increase service life potential of tires and insure good braking performance, tires must be maintained in good condition. In addition to correct inflation this means proper matching of tire pairs, frequent inspection for condition, good judgment of tire serviceability, and good housekeeping habits.

Air pressure between paired tires should not vary over five pounds. Air pressure loss during a 24-hour period should not exceed 5 per cent; if it does, the tire should be replaced. New tires should be rechecked 24 hours after installation because they have a tendency to "grow" a little, thereby reducing pressure.

When checking air pressure, the valve should be inspected for leaks, using the bubble test. It should be determined that each valve has a cap and that it is securely installed. The cap will protect the valve against air escaping, should a valve core develop a leak during flight.

Before installing a tire, the airplane should be jacked and the installed tire measured. Normally, the tire will be out of round since it will take a temporary set after standing. The largest diameter should be measured and a tire of the same diameter, within the following tolerances, installed.

- When installing a new or used nose gear tire, it should be matched within 1.2 inches of the installed tire, if manufacturer and tread wear are equal. If nose gear tires are not properly matched, the airplane has a tendency to pull to one side.
- The circumferential difference between main landing gear tires on the same axle is three inches. Use of a new and a badly worn tire of the same manufacturer will not exceed this limit, thereby making it easy to maintain the 3-inch tolerance. Exceeding this limit will cause excessive twisting of the truck.

Tires require inspection after a hard landing and at each preflight. Cuts, bruises, breaks, loose tread, blisters, and uneven or excessive wear are things to look for.

Flat spots and skid burns are usually the result of a "hot" or severe landing. If the center tread dimples are still visible even though the fabric at the edges seems to be frayed, the tire still has a few more normal landings available. If fabric has worn down past the center dimples, the tire is retreadable, and it should be removed from service. If tread is down to where cords are visible, the tire is no longer retreadable, and, of course, it should be removed from service.

Cause and effect are two sides of one fact.— EMERSON

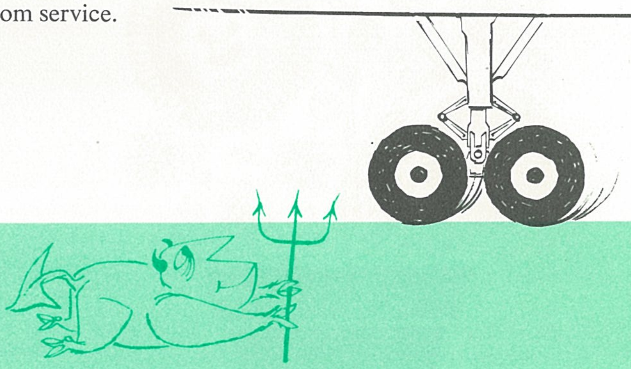
A bruise on a tire is normally indicated by a bulge; however, bulges may also indicate tread separation or damage to the body core. In any event, the tire so damaged, should be removed from service. Bruised tires are usually caused by running over large obstructions or rolling off the runway. When a tire is subjected to this type of punishment, it should be thoroughly inspected for damage.

A gaping transverse cut more than ½ inch long in the tread sidewall is cause for removal as is a gaping circumferential 1½ inch cut that extends through the tread. These cuts are probably the result of the tire rolling over sharp objects.

A tire from which the retread has separated should be removed from service. Important, too, is that a thorough inspection be made of aircraft structure for damage, door malfunction, etc as a result of the tire throwing a tread.

Contact with hard, sharp objects, such as rivets, bolts, rocks, etc, is the cause of most tire damage. To preclude this major source of premature tire removals and/or scrapping, ramps, taxiways, runways, and hangar floors should be swept clean of such items. Maintenance personnel should be cautioned not to drop small objects, to pick up those they see, and to dispose of them in the proper manner.

It is also important to keep hangar floors, runways, and ramps free of oil. Oil deteriorates both natural and synthetic rubber. If tires are permitted to stand in puddles of oil, or oil is permitted to drip on a tire until the tire is oil-soaked, the rubber becomes spongy and tacky to the touch. Such tires are to be removed from service.



The causes of events are ever more interesting than the events themselves. — CICERO

6 40

Handling of Toxic Materials

Mighty is the force of habit. — CICERO

The handling of toxic materials requires a special knowledge of the material—chemical, physical and toxicological properties; an understanding of the hazards involved—fumes and vapors, fire and explosion; and the tools and clothing necessary for protection.

Many of the materials used in general shop and aircraft maintenance have become so much a part of the maintenance man's daily routine that he tends to disregard the precautions necessary in their use. This apathy in the use of solvents containing volatile and explosive properties can cause injury—even death—and damage to equipment.

Injury and death can result from inhalation of fumes and vapors over long periods of time. Some fumes and vapors can damage lung and throat tissues, internal organs, blood, and the nervous system. If it is determined that fumes and vapors will be present, adequate ventilation should be provided. Respiratory equipment may be required. This equipment should be kept in good condition—faceplate and hoses in good repair, and air cylinders properly charged.

Some toxic materials can be absorbed through the skin, damaging internal organs and blood, and resulting in damage to the nervous system. Protective clothing should be worn to protect against this type injury. Rubber aprons, gloves, goggles, and face shields are usually prescribed to avoid contact with such materials. If a toxic chemical contacts the skin, it should be washed off immediately. If it should contact the eyes, they should be flushed continually with water until medical aid can be summoned. Clothing which has been exposed to toxic chemicals should not be worn until washed.

Ingestion of toxic materials may be attributed to unclean personal habits—eating or smoking without first washing the hands. Such ingestion can damage the digestive tract and other internal organs.

When working with volatile and flammable materials, adequate ventilation should be provided and the compound kept away from open flames. These materials can burn with combustive force. Clothing that will not support combustion should be worn if there is danger of fire during use.

Incidents of fire and explosion in the careless handling of oxygen indicates the need for adequate instructions in the handling of this material. The information isn't new but it requires repeating.

Oxygen, a tasteless, odorless gas, can erupt with explosive force when in contact with grease or oil. Before working on oxygen equipment, hands, tools, and fittings should be wiped free of petroleum products. Even a greasy rag in the area, or grease spots on clothing, can cause a violent explosion if permitted to come in contact with a stream of oxygen.

Do not permit smoking during any oxygen purging or testing procedure. Fires in which oxygen is involved cannot be smothered since the required oxygen is furnished to support combustion.

Do not loosen or tighten line fittings until all pressure has been bled from the system.

Do not permit oxygen to escape into a confined area since this will create an extremely serious explosion hazard.

Open valves in oxygen lines very slowly to prevent generation of heat from pressure surges. The heat from pressure surges could be as high as 1700° F, which is sufficient to ignite materials with explosive force.

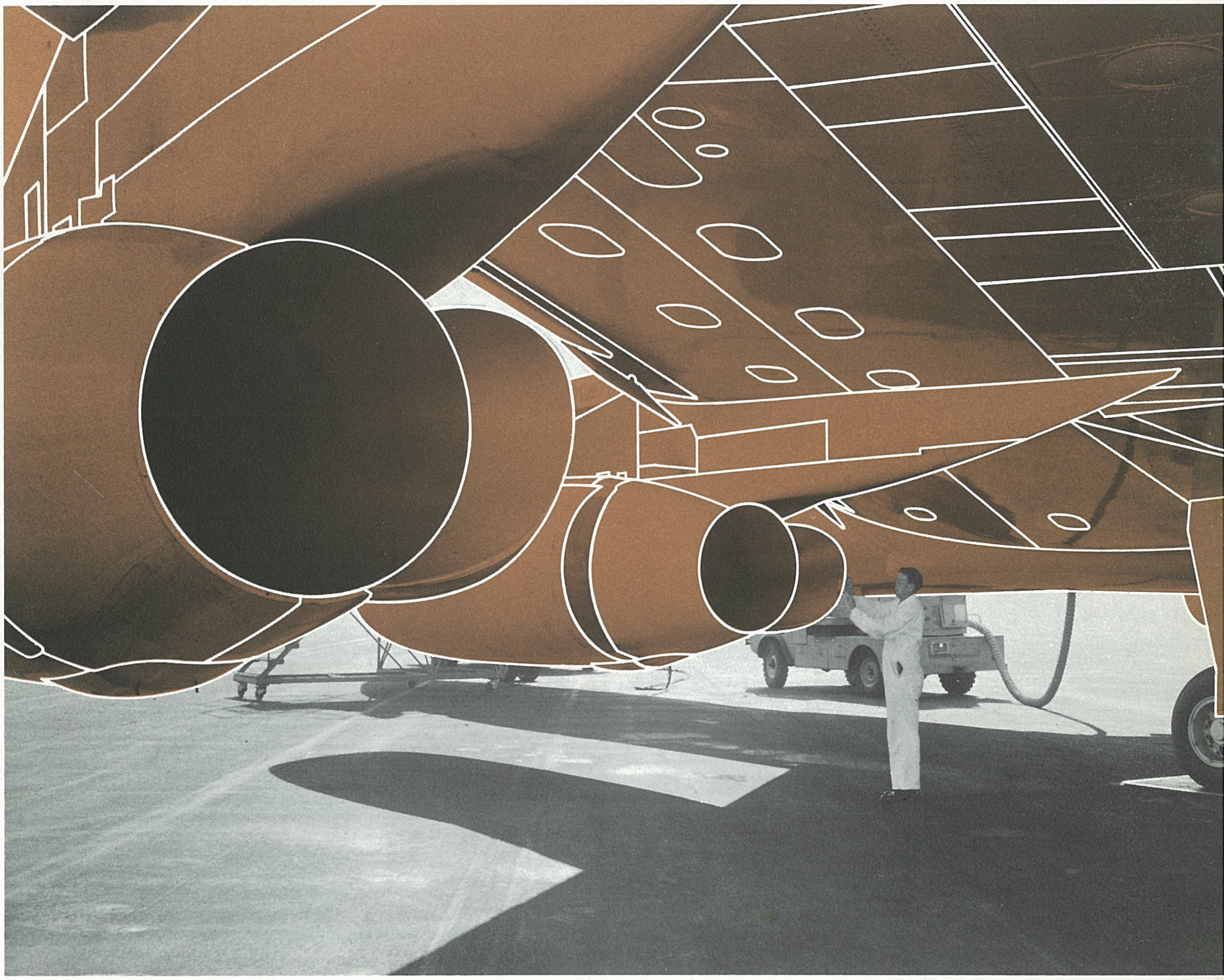
Oxygen, when properly used, is an indispensable gas; improperly used or handled, it becomes a readily explosive material.

There is no magic key, or standardized formula, for safety in aircraft maintenance. But, a well-integrated and well-informed maintenance crew with efficient and proper support equipment can 1) provide convenience and safety for passengers without exposing them to discomforts; 2) meet schedules without compromising integrity of the aircraft; 3) cut costs without sacrificing service and personnel.

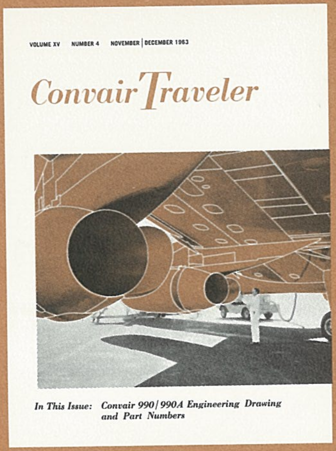
Proverbs are short sentences drawn from long experience. — CERVANTES

VOLUME XV NUMBER 4 NOVEMBER | DECEMBER 1963

Convair Traveler



In This Issue: Convair 990/990A Engineering Drawing and Part Numbers


VOLUME XV NUMBER 4 NOVEMBER|DECEMBER 1963

Convair Traveler

In This Issue: Convair 990/990A Engineering Drawing and Part Numbers

OUR COVER

Artist George Paul neatly dissects a Convair 990A wing with a few white lines. It's not so easy to do in the field, and it helps to have a few blueprints around to refer to, especially when the wing has to be put together again. This issue shows where to find the blueprints.

Convair Traveler

VOLUME XV NUMBER 4 NOVEMBER/DECEMBER 1963

MANAGER, CUSTOMER SERVICE — O. W. HARPER
CHIEF ENGINEERING SERVICE — L. J. BORDELON
CHIEF, FIELD SERVICE — R. W. SOMMERS
CHIEF, SERVICE PARTS — J. DOIG
CHIEF, TECHNICAL PUBLICATIONS — H. R. KENNEDY
EDITOR — GERTRUDE S. HUNTER

IN THIS ISSUE

CONVAIR 990/990A ENGINEERING DRAWING AND PART NUMBERS
Hugh R. Smith

CORRECTION

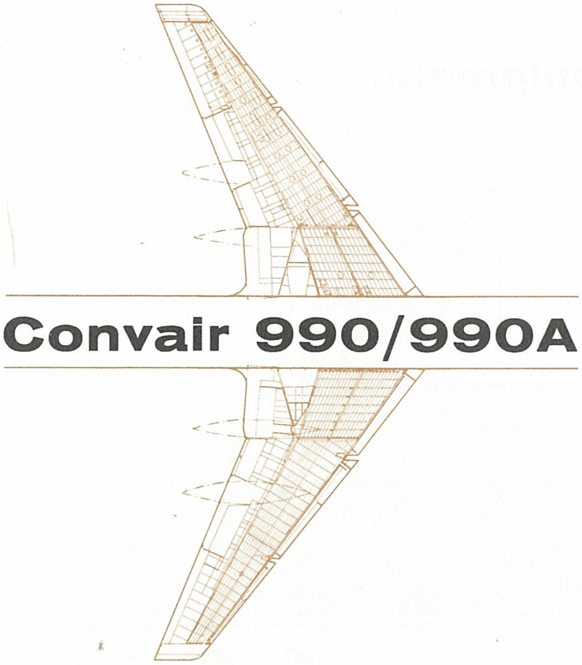
On page 3 of the July-August Traveler, reference is made to Drawing 22-00007, for customer identification of 880 model numbers. The drawing is 30-00007, for all 880/990 models.

Incidentally, the paragraph preceding this error made a point of warning against exactly this mistake—failing to note the proper 22- or 30-drawing number prefix. This, the Traveler admits, is making the point the hard way.

A digest of operation and service published monthly by the Technical Publications Section of GD|Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics|Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

COPYRIGHT 1963

Convair 990/990A Engineering Drawing and Part Numbers



THIS ISSUE OF THE TRAVELER is intended for use as a quick-reference index to Convair 990 and 990A drawing numbers.

As in a similar issue covering the Convair 880/880M (July-August 1963), the first list, on this and the following pages, is of major assembly drawings, system schematics, component lists and general arrangement drawings. These are particularly useful in running down detail drawings of airframe or system components. The electrical system is not covered; the best system drawing indexes are those in the Wiring Diagram Manuals.

The other pages carry sketches labelled with 990/990A part numbers. Vendor-manufactured items, including most of the furnishings and electronic equipment, bear installation drawing numbers; airframe components for the most part bear assembly or detail part numbers, unless specifically labelled as installation drawings.

Version differences are usually specified by limiting the callout to Model 30-5, 30-6, or 30-8, the three basic models of the 990. These are cross-referenced with customer identification and registration numbers in Drawing 30-00007, and also in the Introduction to the Maintenance Manual. In a few instances, where major differences exist between different customer versions of the same model, it has been necessary to refer to a specific airline configuration.

All Convair 990's are slated to be modified to 990A's. However, since the modification program may not be complete for some months, there are sketches for both 990 and 990A wing leading edges and pod-pylons, where the principal differences exist.

Few dash numbers and effectivities appear; the drawings themselves and their associated EDP lists must be consulted for maintenance or procurement purposes.

Major Drawings

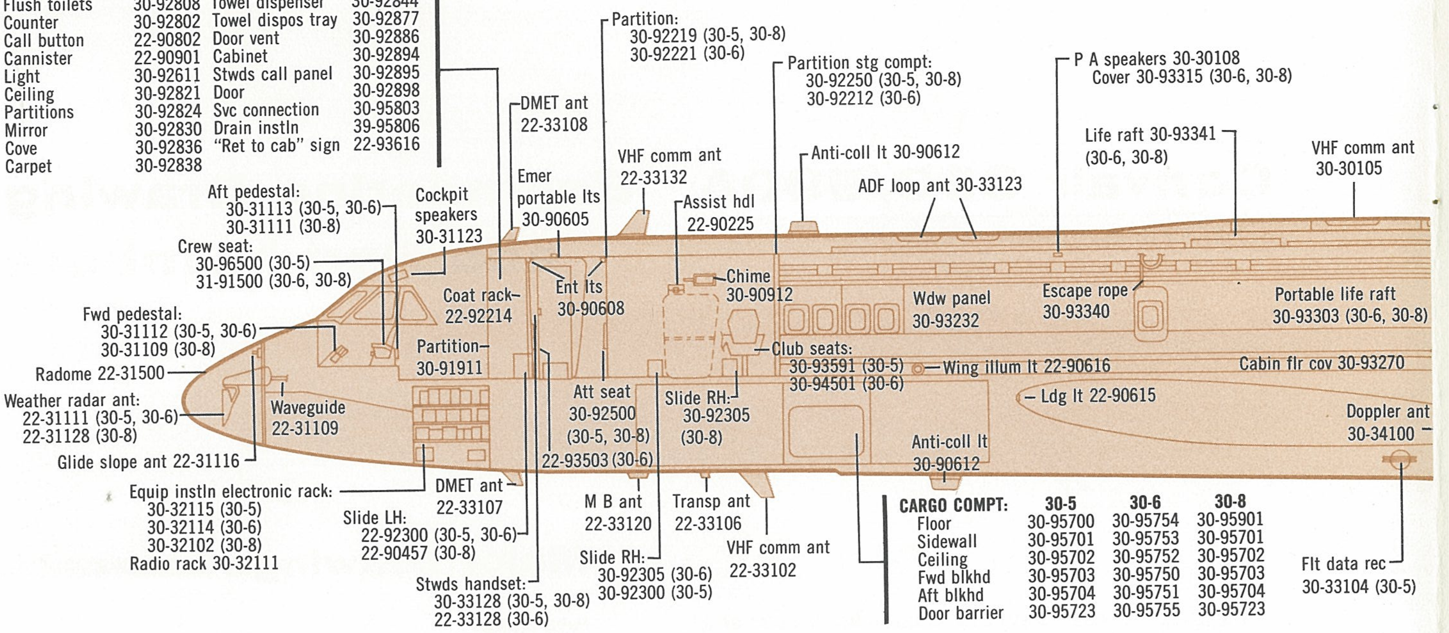
FURNISHINGS

General (list):	
Model 30-5	30-90005
Model 30-6	30-90006
Model 30-8	30-90008
General arrangement outline:	
Model 30-5	30-90213
Model 30-6	30-90214
Model 30-8	30-90212
Insulation:	
Cockpit	22-90201
Cabin:	
Sta 306-678	30-90201
Sta 678-964	30-90202
Sta 964-1488	30-90204
Overwing box	22-90203
Main wheel well	30-90203
Over hydraulic compt	30-90207
Cabin air ducts	22-90210
Placards, passenger area	30-90211
Model 30-8	30-90216
Oxygen system:	
Installation:	
Model 30-5	30-90400
Model 30-6	30-90420
Model 30-8	30-90413
Schematic:	
Model 30-5	30-90401
Model 30-6	30-90411
Model 30-8	30-90414
Pitot-static system:	
Installation	30-90403
Schematic	30-90404
Water equipment:	
Installation:	
Model 30-5	30-95410
Model 30-6, 30-8	30-95404
Schematic:	
Model 30-5	30-95411
Model 30-6, 30-8	30-95403
Lavatory plumbing diagram	30-95813
Exterior lights	30-90610

ELECTRONIC EQUIPMENT

General arrangement:	
Model 30-5	30-30001
Model 30-6	30-30006
Model 30-8	30-30008

Furnishings and Electronic Equipment



FORWARD LAVATORIES:

Flush toilets	30-92808	Towel dispenser	30-92844
Counter	30-92802	Towel dispos tray	30-92877
Call button	22-90802	Door vent	30-92886
Cannister	22-90901	Cabinet	30-92894
Light	30-92611	Stwds call panel	30-92895
Ceiling	30-92821	Door	30-92898
Partitions	30-92824	Svc connection	30-95803
Mirror	30-92830	Drain instln	39-95806
Cove	30-92836	"Ret to cab" sign	22-93616
Carpet	30-92838		

CARGO COMPT:	30-5	30-6	30-8
Floor	30-95700	30-95754	30-95901
Sidewall	30-95701	30-95753	30-95701
Ceiling	30-95702	30-95752	30-95702
Fwd blkhd	30-95703	30-95750	30-95703
Aft blkhd	30-95704	30-95751	30-95704
Door barrier	30-95723	30-95755	30-95723

Equipment installation, electronics rack:	
Model 30-5	30-32115
Model 30-6	30-32114
Model 30-8	30-32102

AIR CONDITIONING & PRESSURIZATION

System installation	30-29000
System schematics:	
Electric Freon drive	30-02001
Pneumatic Freon drive	30-02000
(NOTE: In schematics, 990A modification drawings are coded "DR".)	
Equipment installation underwing	30-29003
Low-pressure pneumatic tubing isometric	30-20000
Ducting:	
Under floor	30-28023
Cabin air supply	30-28054
	22-28067
Flight compartment	22-28000
Wing bleed air	30-27119
	30-27074
Rainclearing	22-27104
	22-27105
Underwing bleed air	22-29011
Electronic cooling	22-28090
Pylon	30-27000
Wing anti-ice	30-27061
	30-27065
	30-27068
Slat anti-ice (990)	30-27017
	30-27049
Overheat detection system:	
Wing bleed air duct	30-27052
	30-27073
	30-27088
Wing bleed air space sensors	22-27053
	30-27089
Fuselage rainclearing duct space sensors	30-27055
Underwing duct space sensors	22-27056
Pod-pylon	30-27057

CONTROLS

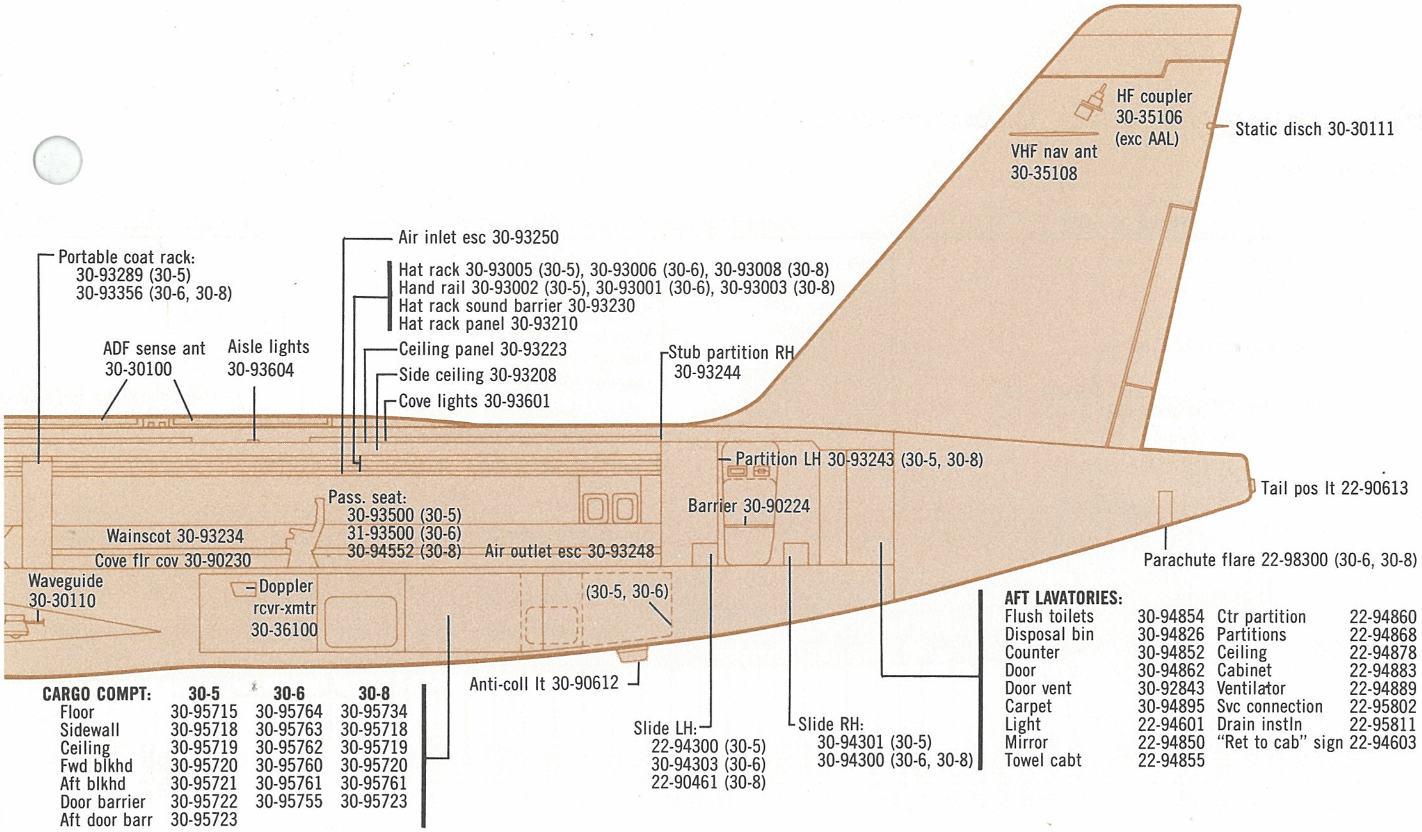
Control systems—general	30-40000
Slats (990)	30-40001
Rudder (fuselage area)	30-40002
Rudder trim (fuselage area)	30-40006
Rudder & trim controls (empennage)	30-40021
Elevator	30-40003
Aileron—spoiler—speedbrakes	30-40004
Flaps	30-40005
Engine	30-40007
Autopilot	30-40008
Landing gear	30-40010
Nose wheel steering	30-40011
Brake	30-40012
Landing gear emergency extension	30-40013
Stabilizer trim	30-40016
Aileron trim	30-40017
Fairleads	30-40009
Cable assembly	30-40911
Control column installation	30-41000
Pedestal installation	30-41001
Landing gear lever	22-41005
Parking hand brake	22-41004
Rudder pedal installation	22-41200

FUEL SYSTEM

System schematics:	
Model 30-5	30-21440
Model 30-6, 30-8	30-21576
Subsystem installation:	
Engine fuel supply	30-21400
Refuel-defuel	30-21470
Fuel gaging	30-21450
Vent	30-21500
Jettison	30-21550

HYDRAULICS

Hydraulic equipment installation	30-80000
Tubing:	
Fwd of Sta 678	30-80100
Aft of Sta 964	30-80102
Wing	30-80103
990A modification drawing	30-80104
Schematics:	
Systems 1 & 2	30-80001
Krueger flaps (990A)	30-80009
Nose landing gear brakes (990A)	30-80010


HF coupler 30-35106 (exc AAL)
Static disch 30-30111
VHF nav ant 30-35108
Air inlet esc 30-93250
Portable coat rack: 30-93289 (30-5) 30-93356 (30-6, 30-8)
Hat rack 30-93005 (30-5), 30-93006 (30-6), 30-93008 (30-8)
Hand rail 30-93002 (30-5), 30-93001 (30-6), 30-93003 (30-8)
Hat rack sound barrier 30-93230
Hat rack panel 30-93210
ADF sense ant 30-30100
Aisle lights 30-93604
Ceiling panel 30-93223
Side ceiling 30-93208
Cove lights 30-93601
Stub partition RH 30-93244
Partition LH 30-93243 (30-5, 30-8)
Tail pos lt 22-90613
Pass. seat: 30-93500 (30-5) 31-93500 (30-6) 30-94552 (30-8)
Barrier 30-90224
Wainscot 30-93234
Cove flr cov 30-90230
Air outlet esc 30-93248
Parachute flare 22-98300 (30-6, 30-8)
Waveguide 30-30110
Doppler rcvr-xmtr 30-36100
(30-5, 30-6)
Anti-coll lt 30-90612
Slide LH: 22-94300 (30-5) 30-94303 (30-6) 22-90461 (30-8)
Slide RH: 30-94301 (30-5) 30-94300 (30-6, 30-8)

CARGO COMPT:	**30-5**	**30-6**	**30-8**
Floor	30-95715	30-95764	30-95734
Sidewall	30-95718	30-95763	30-95718
Ceiling	30-95719	30-95762	30-95719
Fwd blkhd	30-95720	30-95760	30-95720
Aft blkhd	30-95721	30-95761	30-95761
Door barrier	30-95722	30-95755	30-95723
Aft door barr	30-95723		

AFT LAVATORIES:			
Flush toilets	30-94854	Ctr partition	22-94860
Disposal bin	30-94826	Partitions	22-94868
Counter	30-94852	Ceiling	22-94878
Door	30-94862	Cabinet	22-94883
Door vent	30-92843	Ventilator	22-94889
Carpet	30-94895	Svc connection	22-95802
Light	22-94601	Drain instln	22-95811
Mirror	22-94850	"Ret to cab" sign	22-94603
Towel cabt	22-94855		

LANDING GEAR

General arrangement 30-50000
Main landing gear:
  Installation 30-51002
  Door 30-55100
  Door mechanism 30-55101
  Door uplock 30-55102
  Fairing 30-55103
  Aft support 30-55105
  Forward support 30-55106
Nose landing gear:
  Installation 30-52002
  Uplock release 30-52102
  Door 22-71600
  Door uplock 22-52004
  Door mechanism 22-55500
  Bumper 22-52003
  Door uplock release 30-55163

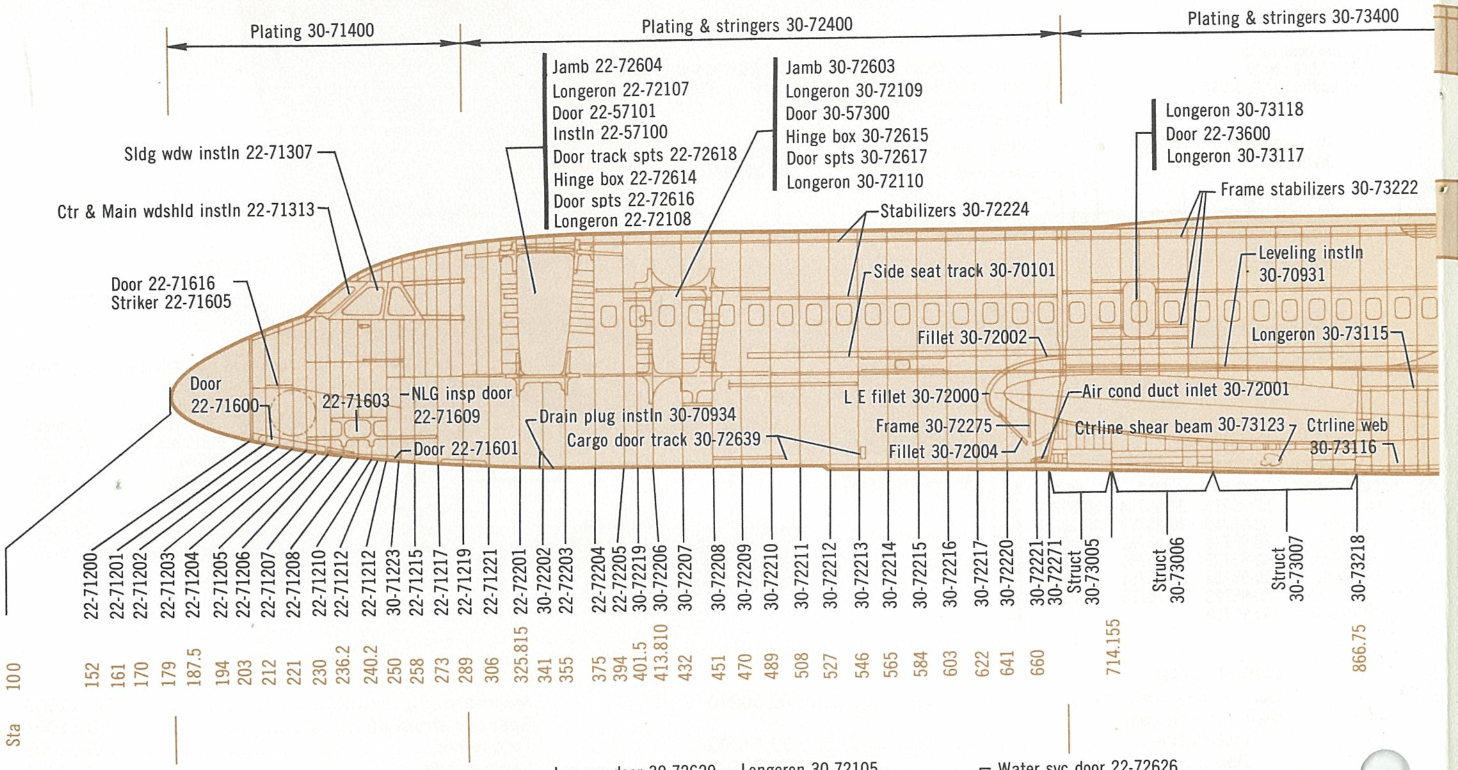
POWER PLANT

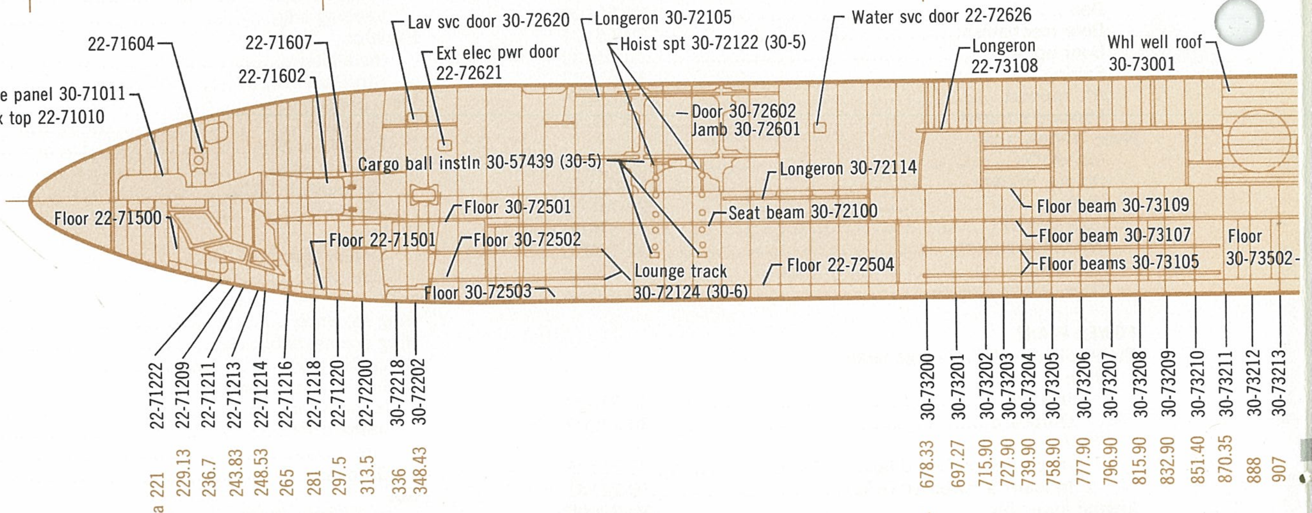
Power plant installation, general:
  990:
    Inboard 30-21000
    Outboard 30-21002
  990A:
    Inboard & outboard (except AAL) 30-21135
    Inboard & outboard (AAL) 30-21141
Engine assembly 30-22000
Engine installation 30-23000
Pylon & fixed pod assembly:
  Inboard 30-24003
  Outboard 30-24004
Pod & pylon assembly:
  Inboard 30-25000
  Outboard 30-25002
Power plant assembly:
  Inboard 30-24000
  Outboard 30-24002
Pod-pylon systems—see p. 14

STRUCTURE

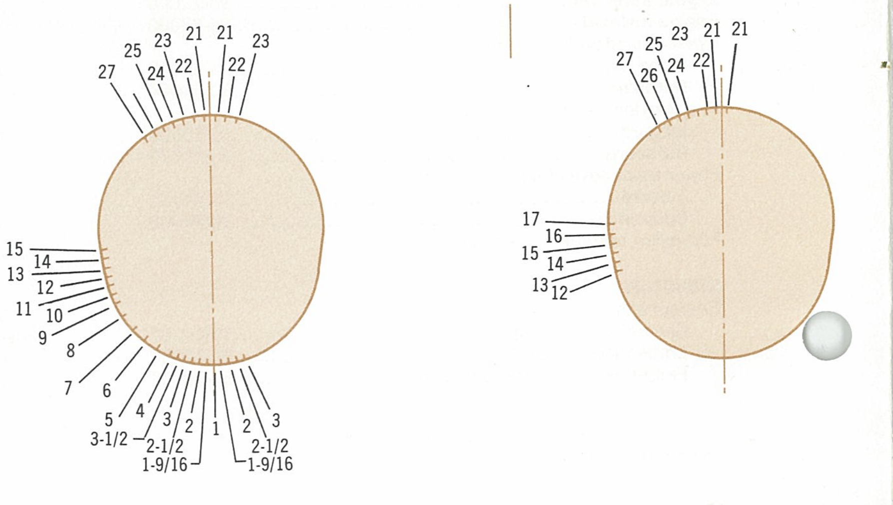
Empennage:
  Geometry & jig diagram 30-00102
  Empennage installation 30-10010
  Empennage equipment installation 30-10011
  Horizontal stabilizer:
    Assembly 30-11000
    Spar box structure 30-11001
    Torque box 30-11003
    Leading edge 22-11004
  Elevator:
    Installation 30-12000
    Structure 30-12001
  Vertical stabilizer:
    Structure 30-14000
    Inner spar box 22-14002
    Leading edge 22-14004
    Tip (except AAL) 22-14900
    Tip (AAL) 30-14900
  Rudder:
    Installation 30-15000
    Structure 30-15001
Wing:
  Wing assembly 30-16000
  Wing box section 30-16001
  Center tie box 30-16020
  Trailing edge sections:
    Inboard forward 30-17005
    Inboard aft 30-17006
    Intermediate 30-17007
    Outboard 30-17008
  Tip:
    Installation (990) 30-19000
    Installation (990A) 30-13043
    Assembly 30-19001
  Aileron:
    Installation 30-18001
    Assembly 30-18000
  Flaps:
    Installation—inboard & outboard 30-18062
    Assembly—inboard 30-18064
    Assembly—outboard 30-18061
  Spoilers:
    Installation—inboard & outboard 30-19053
    Assembly—inboard 30-19050
    Assembly—outboard 30-19051
  Wing drag reduction modification 30-16976
Fuselage:
  General assembly (list) 30-70001
  General arrangement 30-70005

Fuselage

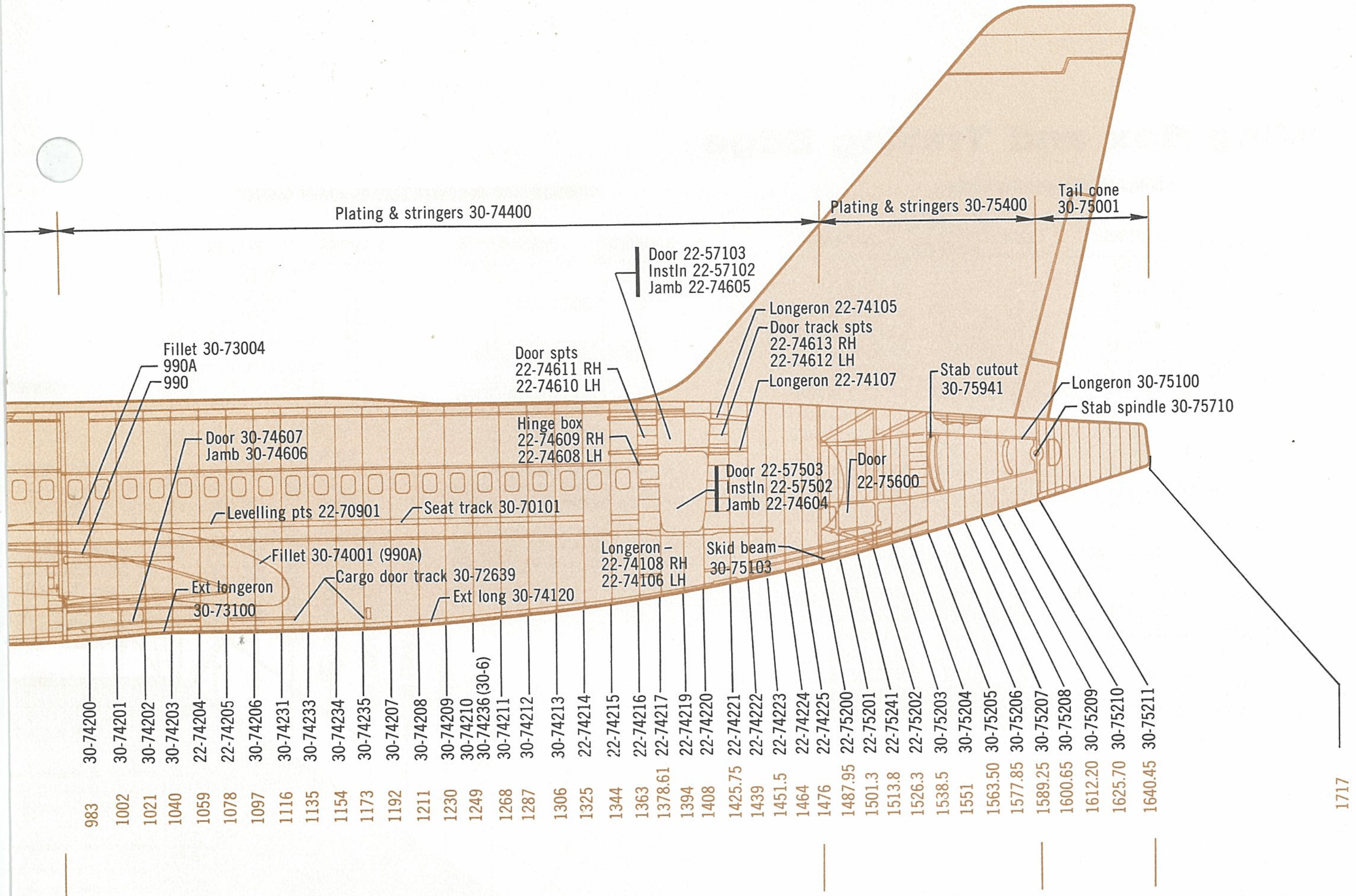


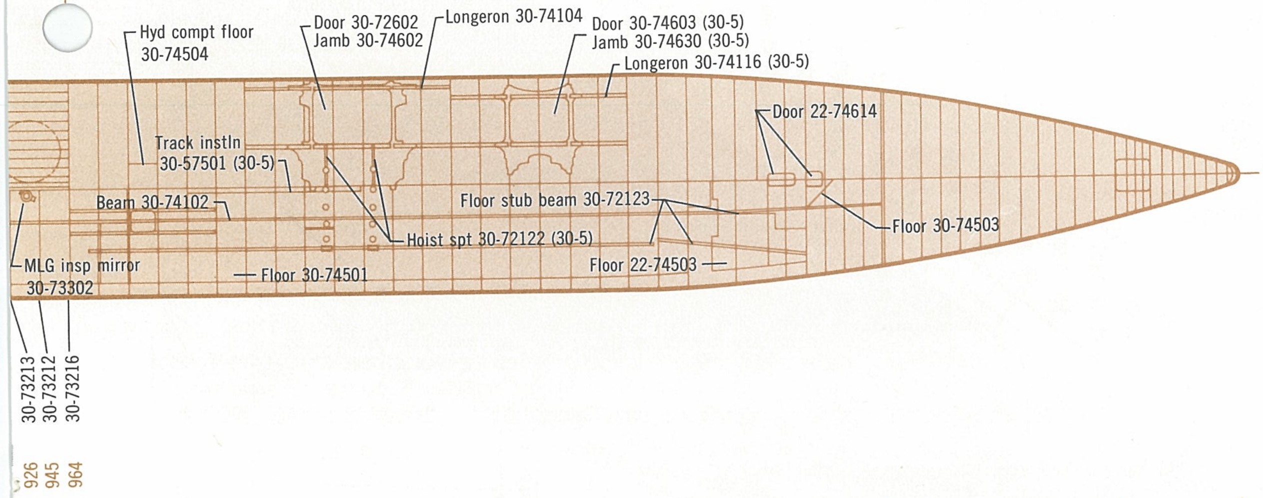


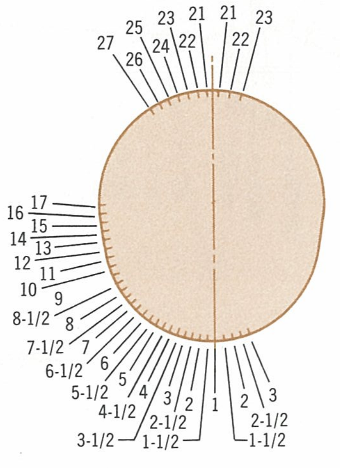
PLAN VIEW

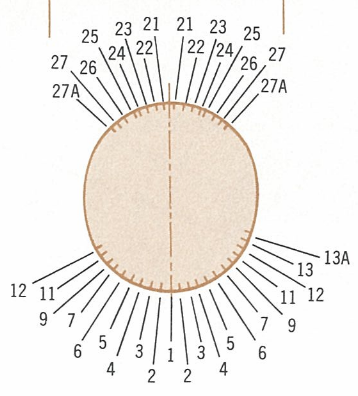


STRINGER NUMBERS


Plating & stringers 30-74400
Plating & stringers 30-75400
Tail cone 30-75001
Door 22-57103
Instln 22-57102
Jamb 22-74605
Longeron 22-74105
Door track spts 22-74613 RH 22-74612 LH
Longeron 22-74107
Door spts 22-74611 RH 22-74610 LH
Hinge box 22-74609 RH 22-74608 LH
Fillet 30-73004
990A
990
Door 30-74607 Jamb 30-74606
Stab cutout 30-75941
Longeron 30-75100
Stab spindle 30-75710
Door 22-57503
Instln 22-57502
Jamb 22-74604
Door 22-75600
Levelling pts 22-70901
Seat track 30-70101
Fillet 30-74001 (990A)
Cargo door track 30-72639
Ext longeron 30-73100
Ext long 30-74120
Longeron – 22-74108 RH 22-74106 LH
Skid beam 30-75103
30-74200
30-74201
30-74202
30-74203
22-74204
22-74205
30-74206
30-74231
30-74233
30-74234
30-74235
30-74207
30-74208
30-74209
30-74210
30-74236 (30-6)
30-74211
30-74212
30-74213
22-74214
22-74215
22-74216
22-74217
22-74219
22-74220
22-74221
22-74222
22-74223
22-74224
22-74225
22-75200
22-75201
22-75241
22-75202
30-75203
30-75204
30-75205
30-75206
30-75207
30-75208
30-75209
30-75210
30-75211
983
1002
1021
1040
1059
1078
1097
1116
1135
1154
1173
1192
1211
1230
1249
1268
1287
1306
1325
1344
1363
1378.61
1394
1408
1425.75
1439
1451.5
1464
1476
1487.95
1501.3
1513.8
1526.3
1538.5
1551
1563.50
1577.85
1589.25
1600.65
1612.20
1625.70
1640.45
1717


Hyd compt floor 30-74504
Door 30-72602 Jamb 30-74602
Longeron 30-74104
Door 30-74603 (30-5) Jamb 30-74630 (30-5)
Longeron 30-74116 (30-5)
Door 22-74614
Track instln 30-57501 (30-5)
Beam 30-74102
Floor stub beam 30-72123
Hoist spt 30-72122 (30-5)
Floor 30-74503
MLG insp mirror 30-73302
Floor 30-74501
Floor 22-74503
30-73213
30-73212
30-73216
926
945
964


8-1/2
7-1/2
6-1/2
5-1/2
4-1/2
2-1/2
3-1/2
1-1/2
2-1/2
1-1/2



Wing Box and Trailing Edge

STRINGERS—WING LOWER SURFACE

STGR	SPAN BLKHD NO.	PART NO.
1	1-3.5	30-16191-7
2	1-7	30-16191-9
3	1-8	30-16191-11
	8-14	30-16193-7
4	1-8	30-16191-13
	8-20	30-16193-27
5	1-3	30-16191-15
	3.5-8	30-16191-17
	8-23	30-16193-25
6	1-8	30-16191-19
	8-23	30-16193-13
	23-34	30-16195-9
7	1-8	30-16191-21
	8-13	30-16193-15
	14-16	30-16193-17(L&R)
	17-19	30-16193-19(L&R)
	20-21	30-16193-21(L&R)
	24-25	30-16195-11
	27-36	30-16195-13
8	1-8	30-16191-23
	8-23	30-16193-23
	23-36	30-16195-15
9	1-3.5	30-16192-7
10	1-7	30-16192-9

STGR	SPAN BLKHD NO.	PART NO.
11	1-8	30-16192-11
	8-23	30-16194-7
	23-36	30-16195-17
12	1-3	30-16192-13
	3.5-8	30-16192-15
	8-13	30-16194-9
	14-16	30-16194-11(R&L)
	17-19	30-16194-13(R&L)
	20-21	30-16194-15(R&L)
	25-26	30-16195-21
	27-29	30-19195-25
	29-36	30-16195-19
13	1-8	30-16192-17
	8-23	30-16194-17
	23-35	30-16195-23
14	1-8	30-16158-7
	8-23	30-16195-19
	23-29	30-16195-27
15	1-8	30-16158-9
	8-22	30-16194-21
16	1-8	30-16192-19
	8-16	30-16194-23
17	1-6	30-16192-21

STRINGERS—WING CENTER SECTION LOWER SURFACE

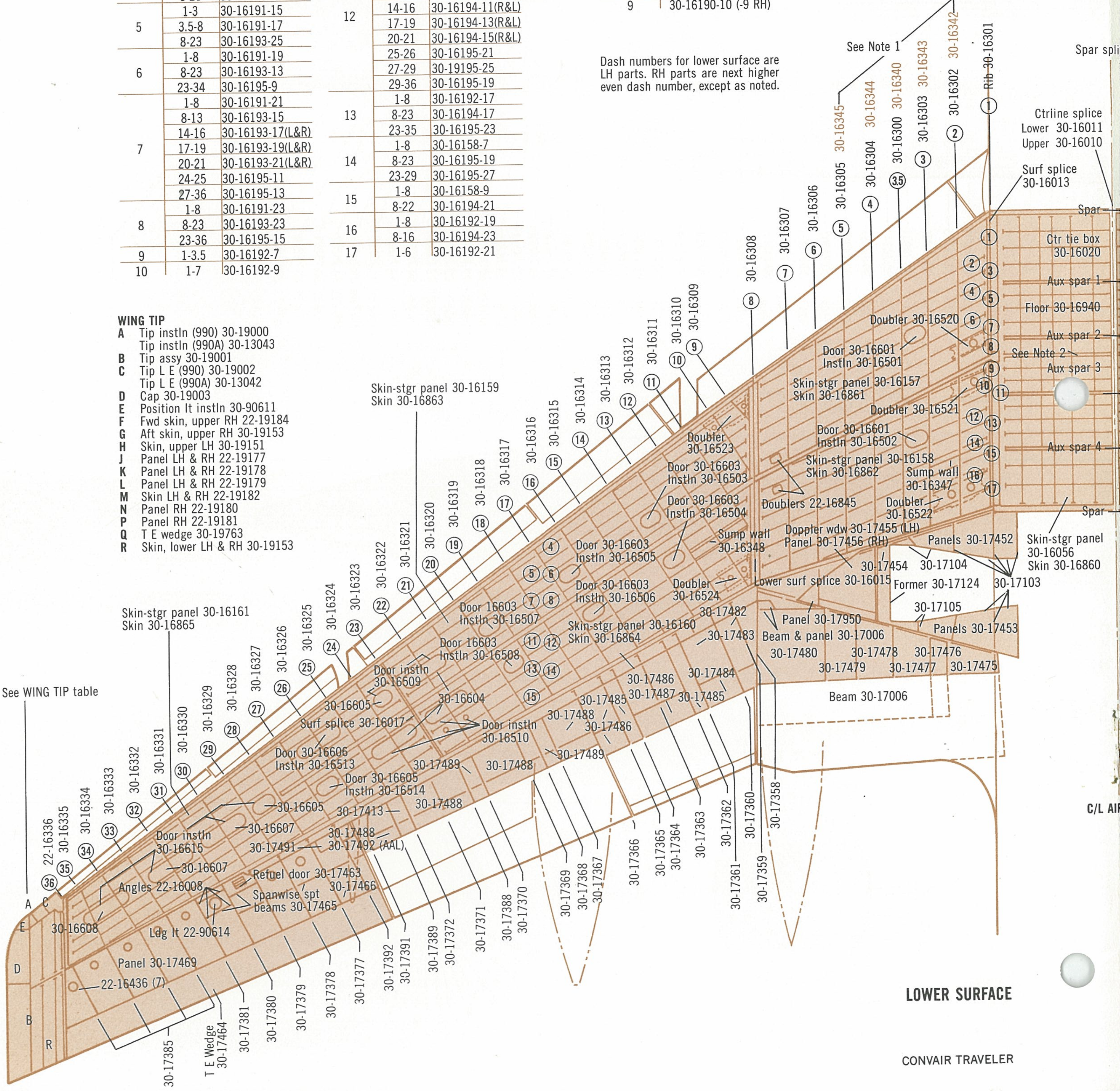
STRINGER	PART NO.
1	30-16190-7
2	
3	
5	
6	30-16190-8 (-7 RH)
7	30-16190-7
9	30-16190-10 (-9 RH)

STRINGER	PART NO.
10	30-16190-10 (-9 RH)
12	30-16190-12 (-11 RH)
13	30-16190-11
14	30-16190-12 (-11 RH)
16	30-16190-14 (-13 RH)
17	

Dash numbers for lower surface are LH parts. RH parts are next higher even dash number, except as noted.

WING TIP

A Tip instln (990) 30-19000
Tip instln (990A) 30-13043
B Tip assy 30-19001
C Tip L E (990) 30-19002
Tip L E (990A) 30-13042
D Cap 30-19003
E Position lt instln 30-90611
F Fwd skin, upper RH 22-19184
G Aft skin, upper RH 30-19153
H Skin, upper LH 30-19151
J Panel LH & RH 22-19177
K Panel LH & RH 22-19178
L Panel LH & RH 22-19179
M Skin LH & RH 22-19182
N Panel RH 22-19180
P Panel RH 22-19181
Q T E wedge 30-19763
R Skin, lower LH & RH 30-19153



LOWER SURFACE

STRINGERS—WING CENTER SECTION UPPER SURFACE

STRINGER	PART NO.
1	30-16150-8
2	30-16170-8
3	30-16150-8
5	30-16150-10
6	
7	30-16150-12
8	
9	30-16170-17 (-18 LH)
11	

STRINGER	PART NO.
12	30-16170-18
13	
15	
16	
17	
18	
20	
21	
22	
23	

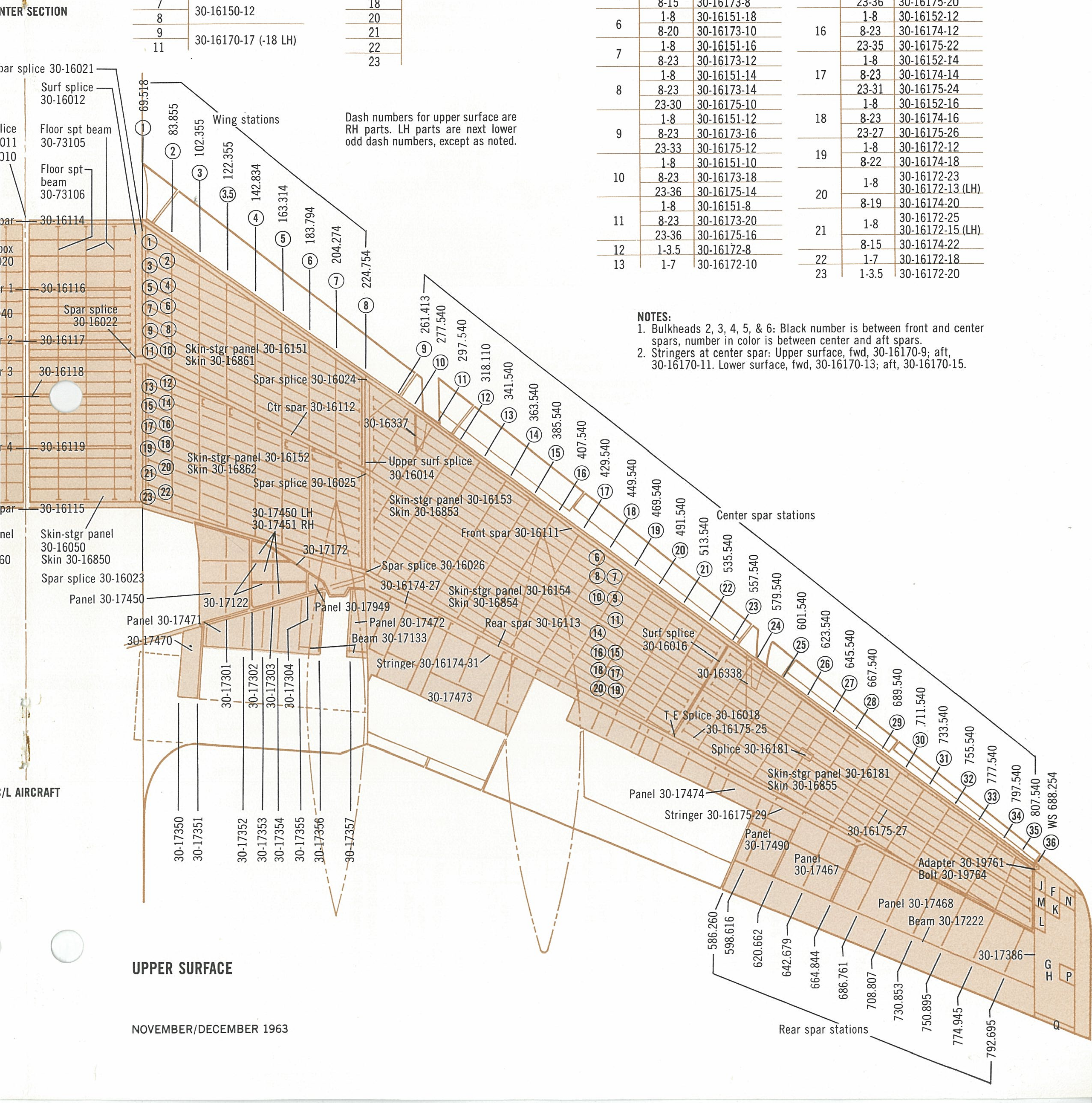
Dash numbers for upper surface are RH parts. LH parts are next lower odd dash numbers, except as noted.

STRINGERS—WING UPPER SURFACE

STGR	SPAN BLKHD NO.	PART NO.
1	1-3.5	30-16171-8
2	1-4	30-16171-10
3	1-7	30-16171-12
4	1-8	30-16171-14
5	1-8	30-16151-20
	8-15	30-16173-8
6	1-8	30-16151-18
	8-20	30-16173-10
7	1-8	30-16151-16
	8-23	30-16173-12
8	1-8	30-16151-14
	8-23	30-16173-14
	23-30	30-16175-10
9	1-8	30-16151-12
	8-23	30-16173-16
	23-33	30-16175-12
10	1-8	30-16151-10
	8-23	30-16173-18
	23-36	30-16175-14
11	1-8	30-16151-8
	8-23	30-16173-20
	23-36	30-16175-16
12	1-3.5	30-16172-8
13	1-7	30-16172-10
14	1-8	30-16152-8
	8-23	30-16174-8
	23-36	30-16175-18
15	1-8	30-16152-10
	8-23	30-16174-10
	23-36	30-16175-20
16	1-8	30-16152-12
	8-23	30-16174-12
	23-35	30-16175-22
17	1-8	30-16152-14
	8-23	30-16174-14
	23-31	30-16175-24
18	1-8	30-16152-16
	8-23	30-16174-16
	23-27	30-16175-26
19	1-8	30-16172-12
	8-22	30-16174-18
20	1-8	30-16172-23 30-16172-13 (LH)
	8-19	30-16174-20
21	1-8	30-16172-25 30-16172-15 (LH)
	8-15	30-16174-22
22	1-7	30-16172-18
23	1-3.5	30-16172-20

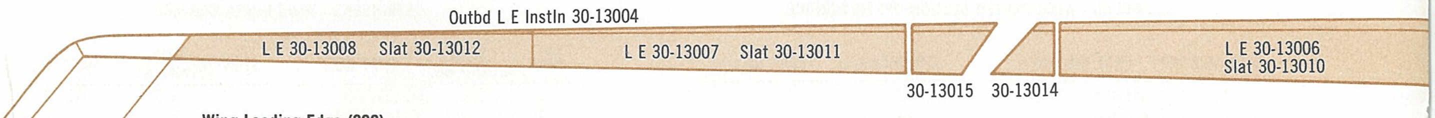
NOTES:

1. Bulkheads 2, 3, 4, 5, & 6: Black number is between front and center spars, number in color is between center and aft spars.
2. Stringers at center spar: Upper surface, fwd, 30-16170-9; aft, 30-16170-11. Lower surface, fwd, 30-16170-13; aft, 30-16170-15.

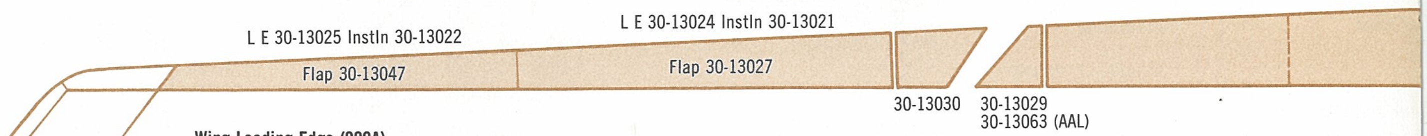


UPPER SURFACE

Wing Leading Edge and Flight Controls

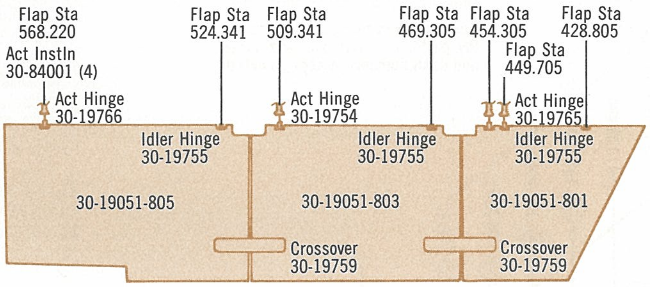

Outbd L E Instln 30-13004
L E 30-13008 Slat 30-13012
L E 30-13007 Slat 30-13011
30-13015
30-13014
L E 30-13006
Slat 30-13010

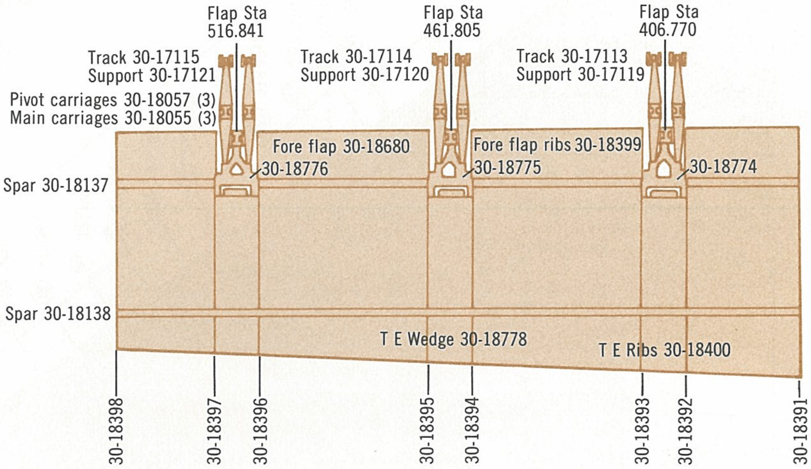
Wing Leading Edge (990)



Wing Leading Edge (990A)

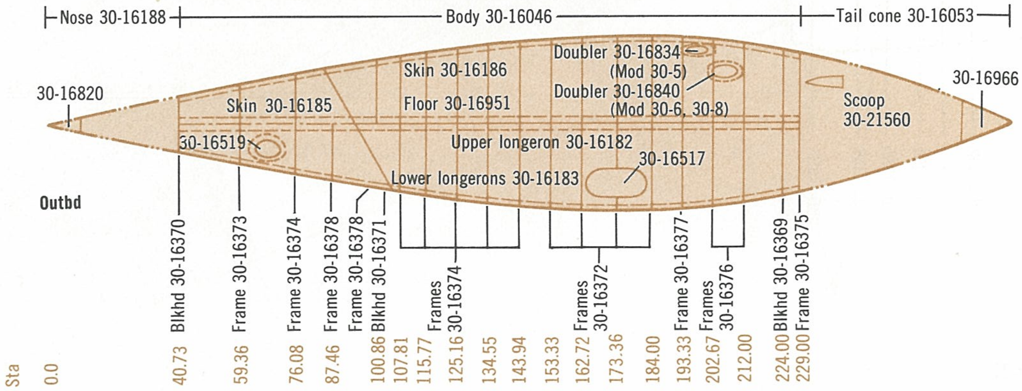
Outbd Spoiler 30-19051, Instln 30-19053

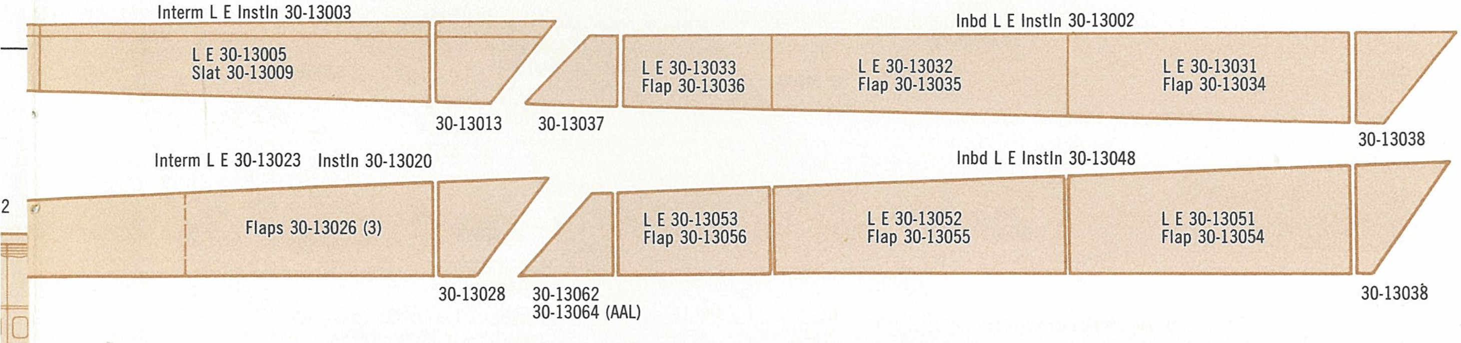


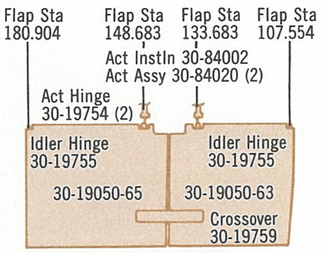


Outbd Flap 30-18061, Instln 30-18062

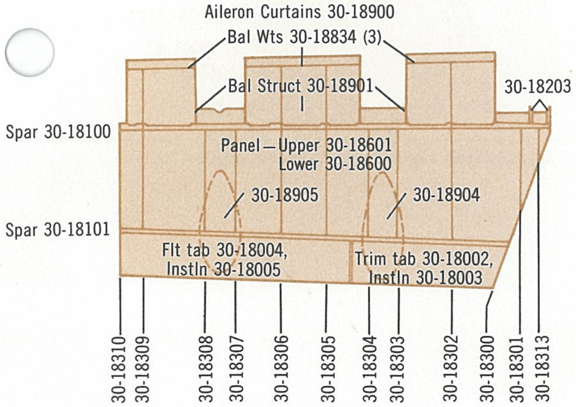
Anti-Shock Bodies



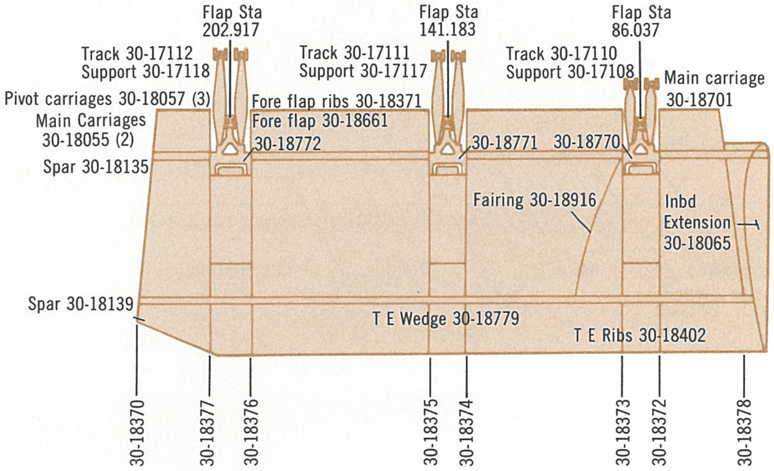




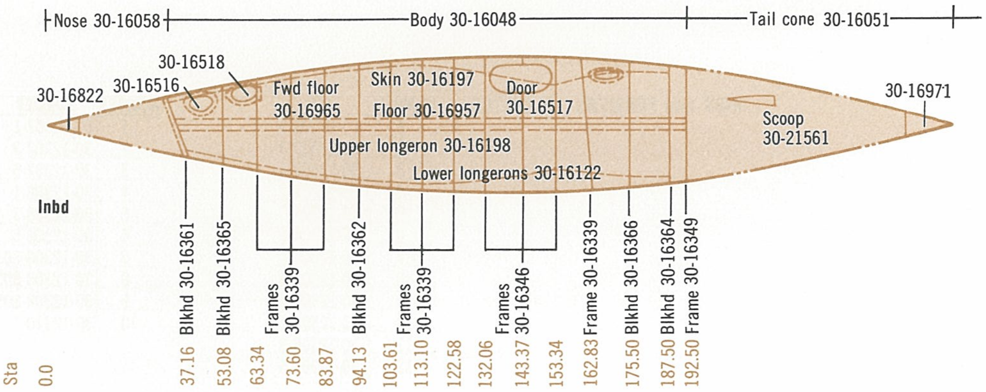
Inbd Spoiler 30-19050, Instln 30-19053



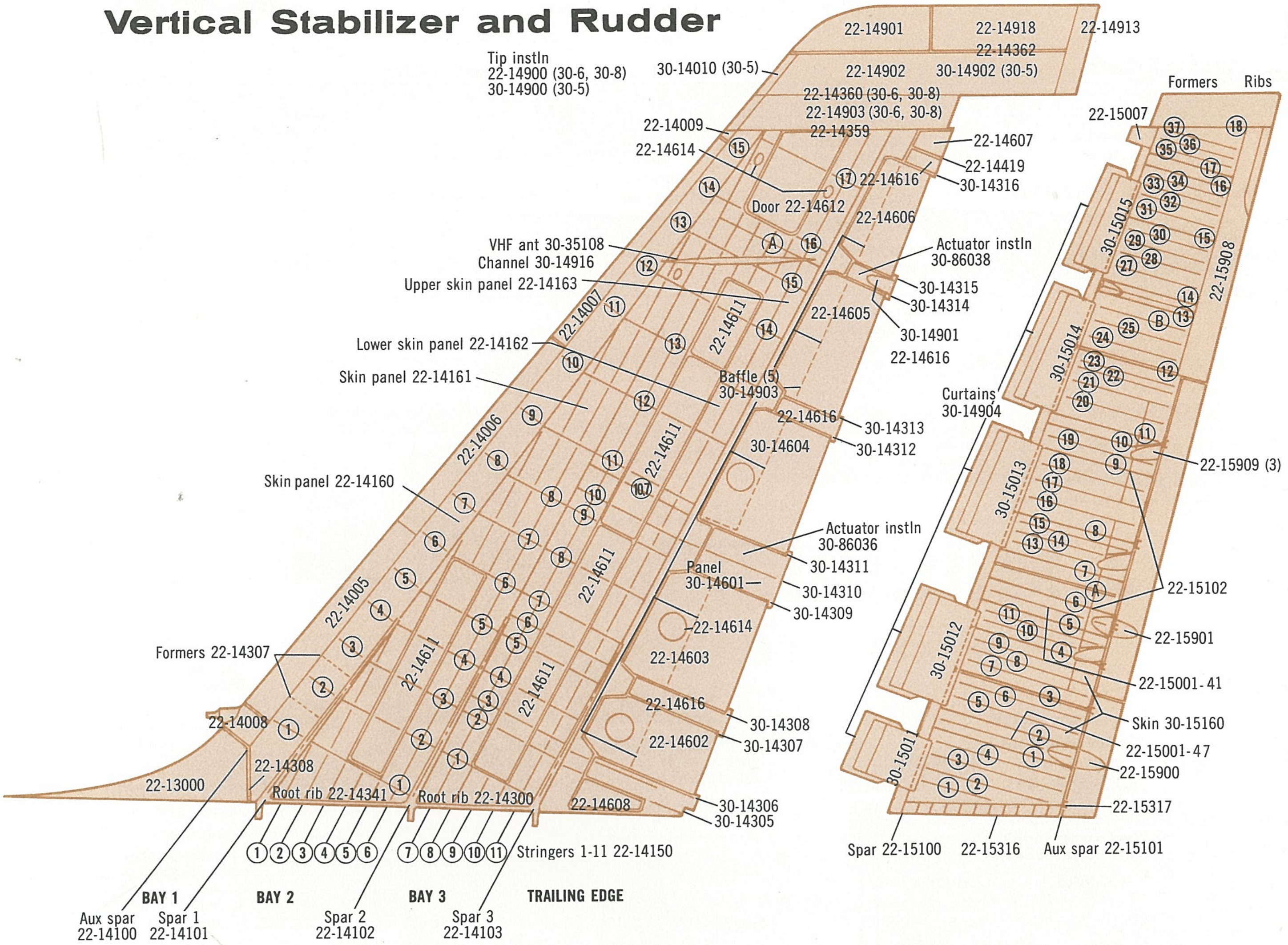
Aileron 30-18000, Instln 30-18001



Inbd Flap 30-18064, Instln 30-18062



Vertical Stabilizer and Rudder

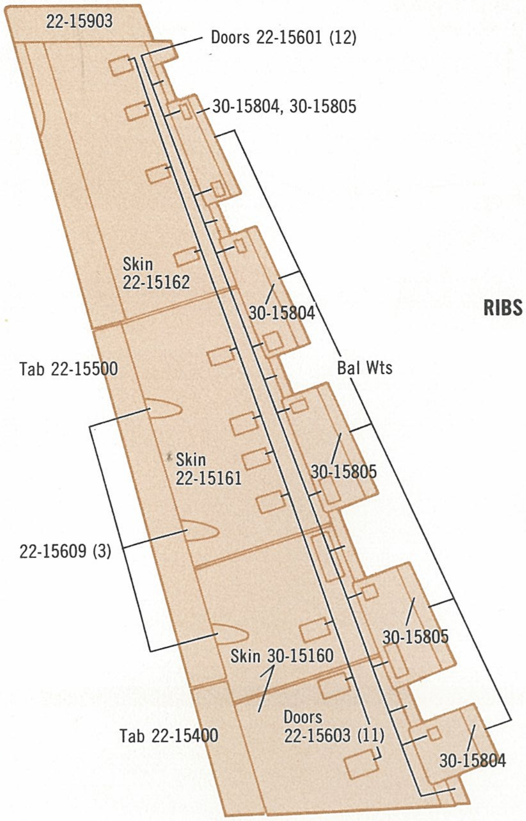


Horizontal Stabilizer and Elevator

RIBS and FORMERS—ELEVATOR

NUMBER	RIB
1	30-12303-1
2	30-12303-3
3	30-12303-5
4	30-12304-1
5	30-12304-3
6	30-12304-5
7	30-12305-1
8	30-12305-3
9	30-12305-5
10	30-12306-1
11	30-12306-3
12	30-12306-5

NUMBER	FORMER
1	30-12307-1
2	30-12307-3
3	30-12307-5
4	30-12308-1
5	30-12308-3
6	30-12308-5
7	30-12308-801
8	30-12308-803
9	30-12308-805
10	30-12310-1



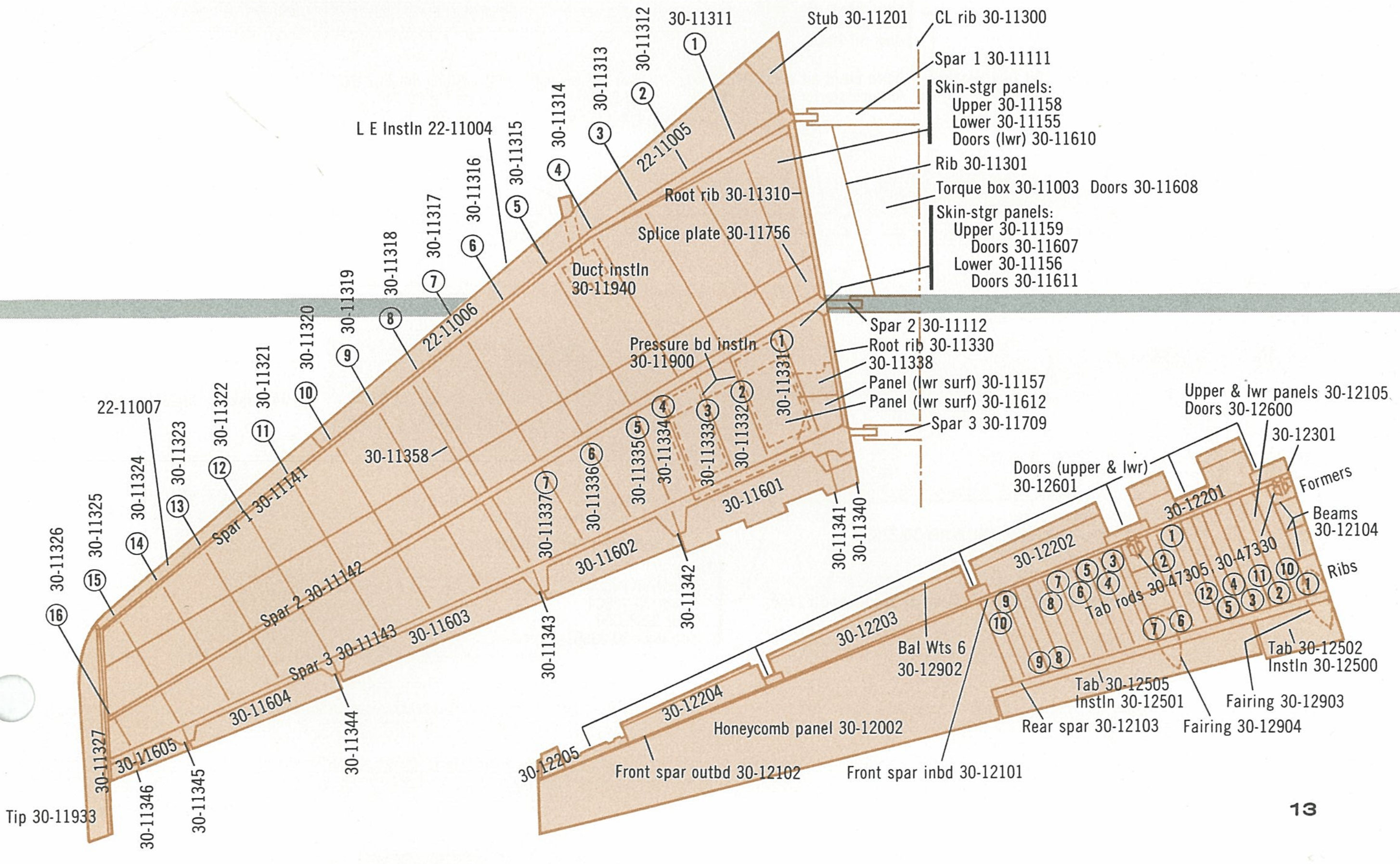
RIBS and FORMERS—RUDDER

RIB	DRAWING
1	22-15301
2	22-15302
3	22-15303
4	22-15304
5	22-15305
6	22-15306
A	30-15353
7-8	22-15307
9	22-15308
10-11	22-15309
12	22-15312
B	30-15359
13 (2), 14	30-15311
15	22-15310
16, 17, 18	22-15313

FORMER	DRAWING
1, 2, 3, 4	22-15350
5, 6, 7	22-15351
8, 9, 10	22-15352
11	22-15353
13, 14, 15	22-15354
16, 17, 18	22-15355
19	22-15356
20, 21, 22	22-15357
23, 24, 25	22-15358
27	22-15359
28, 29, 30	22-15360
31, 32, 33, 34	22-15361
35, 36, 37	22-15362

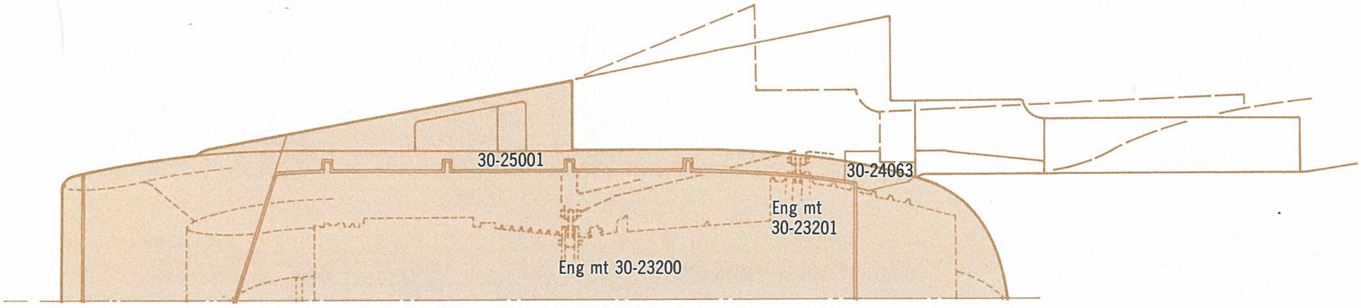
RIBS—VERTICAL STABILIZER

RIB	BAY 1	BAY 2	BAY 3
1	22-14301	22-14321	22-14342
2	22-14302	22-14322	22-14343
3		22-14323	22-14344
4		22-14325	22-14345
5	22-14303	22-14326	22-14346
6		22-14328	22-14347
7		22-14329	22-14348
8	22-14304	22-14330	22-14349
9			22-14350
10			30-14304
10.7			
11	22-14305	22-14352	
12		22-14353	
13		22-14354	
14	22-14306	22-14355	
15		22-14356	
A		30-14363	
16		22-14357	
17			22-14358



Power Plant

990

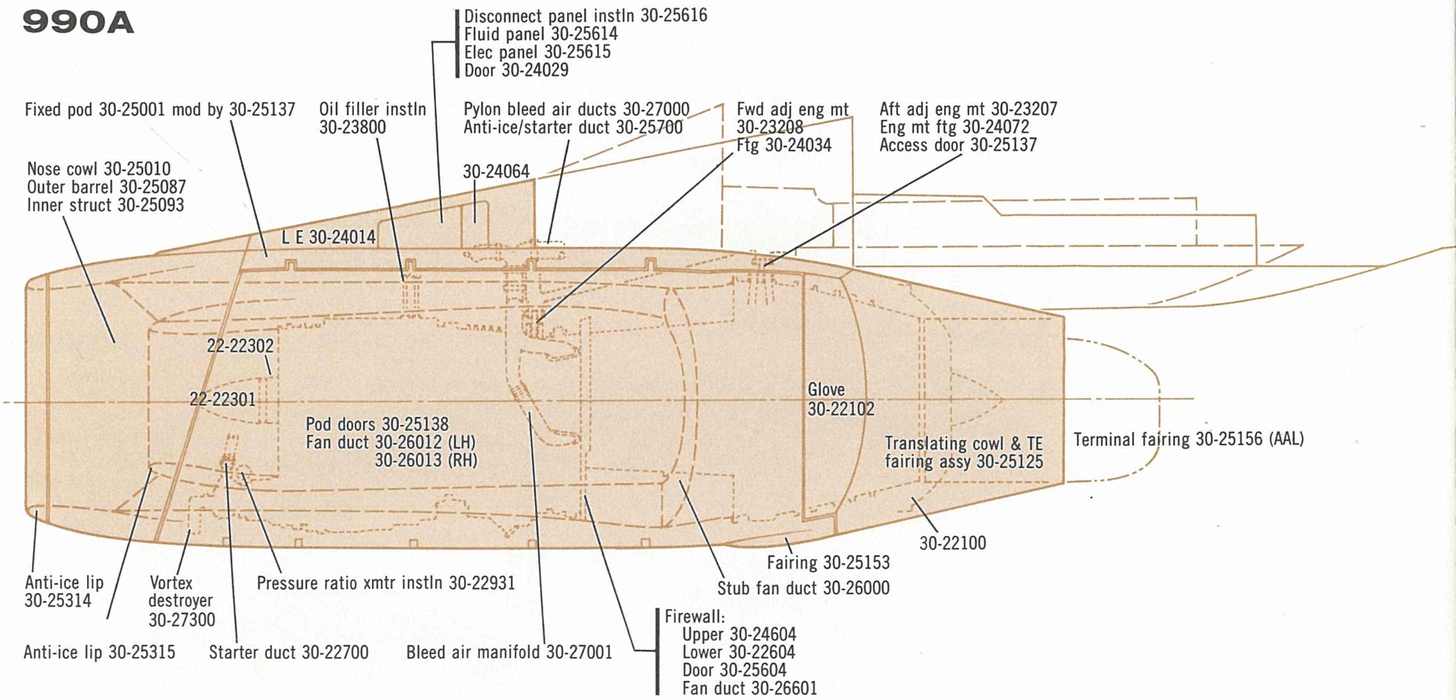


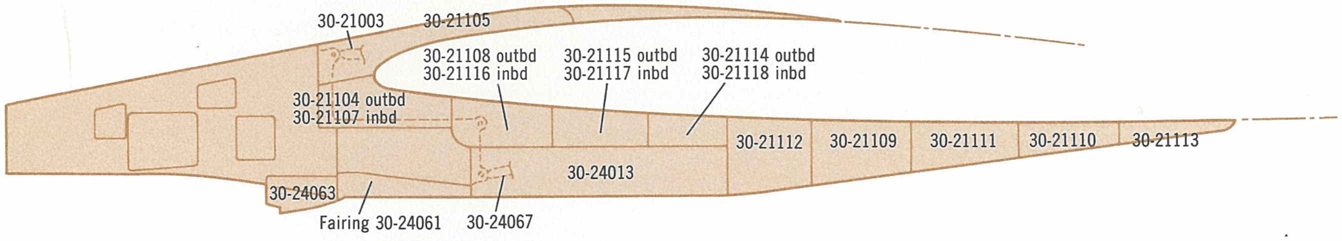
990 pylon L E & fwd pod same as 990A except as noted

Power plant systems (990, 990A):

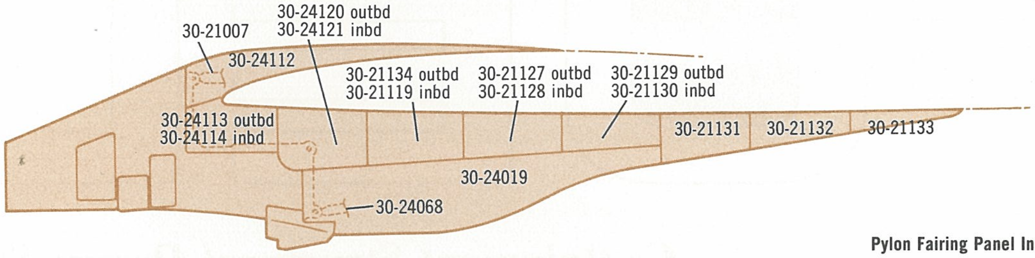
Engine controls	30-45700	Fire extinguishing	30-24600
Tubing	30-20801	Fire & ovht detection	30-24609
	30-20802	Engine drain	30-22901
Fuel tubing	30-22401	Hydraulic filter instln	30-85002
Electrical harnesses	30-00818	Rigging (990A)	30-21143
	30-00819	Rigging (AAL 990A)	30-21144

990A

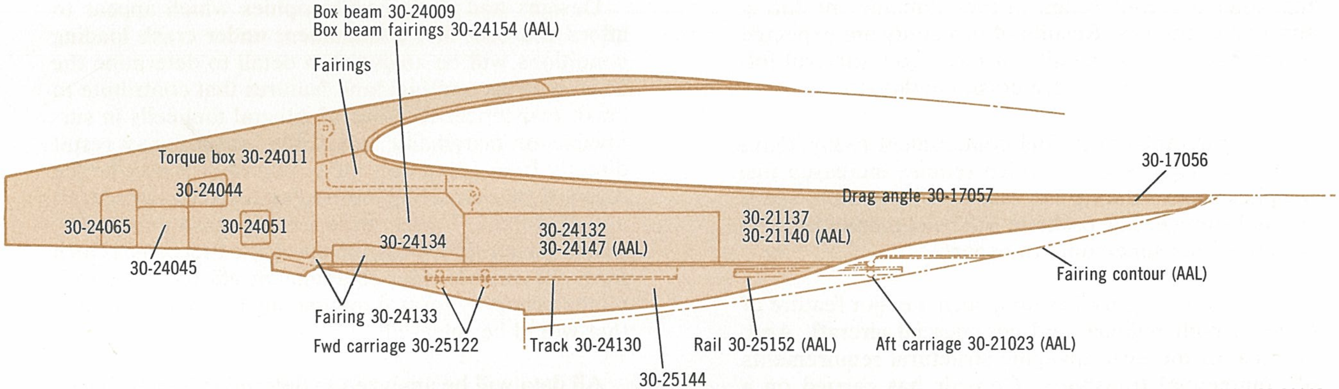




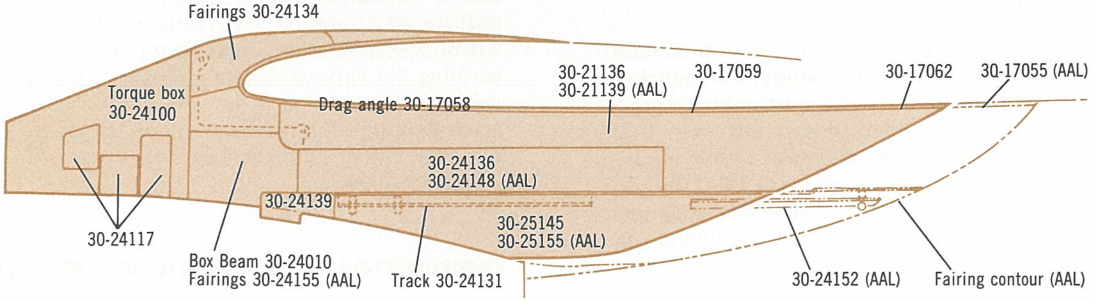
Pylon Fairing Panel Instln—Inbd 30-21100



Pylon Fairing Panel Instln—Outbd 30-21102



Pylon Fairing Panel Instln—Inbd 30-21142



Pylon Fairing Panel Instln—Outbd 30-21142

FUEL

Containment Structural Design Study

GENERAL DYNAMICS/CONVAIR has been awarded a design study contract by the Federal Aviation Agency to investigate structural design principles for containment of fuel during crash landings of commercial transports. Intent of this study is to improve the design of integral fuel tanks and to propose feasible concepts that offer a breakthrough in fuel containment during survivable crashes. Results of this study are expected to increase the probability of passenger survival following moderate-to-severe crash conditions.

A major problem in fuel containment today stems from high flight speeds, which require increased fuel supplies, necessitating the use of all available space for fuel storage. The problem will be compounded with advent of the supersonic transport.

Structural integrity has long been a major feature of Convair-built military and commercial aircraft. And, because of the ever-changing structural requirements of commercial transports, Convair has carried on a continuing test program.

Engineers experienced in the design of commercial transport aircraft will conduct this study. Personnel to participate have contributed to the outstanding service record of Convair-designed transport airplanes that have amassed hundreds of thousands of airline operation hours, and have actively participated not only in the design and testing of these products, but in numerous company-sponsored research and development studies directly related to this study.

In pursuing objectives of the design task, a survey of existing integral fuel cell designs will be made and accident histories will be studied. Data obtained will be analyzed to determine how well particular structures met original design objectives.

Designs and design philosophies which appear to afford the best fuel containment under crash loading conditions will be analyzed in detail to determine the basic reasons and fuel tank features that contribute to crash resistance. Rupture of integral fuel cells in survivable or marginally survivable crashes may result directly from impact on the structure or it may be the result of excessive fuel pressures caused by high deceleration forces. Under more severe crash conditions, where the aircraft wing, including the fuel cells, is torn from the aircraft, fuel containment efforts will be directed primarily toward minimizing the amount of fuel that would be released.

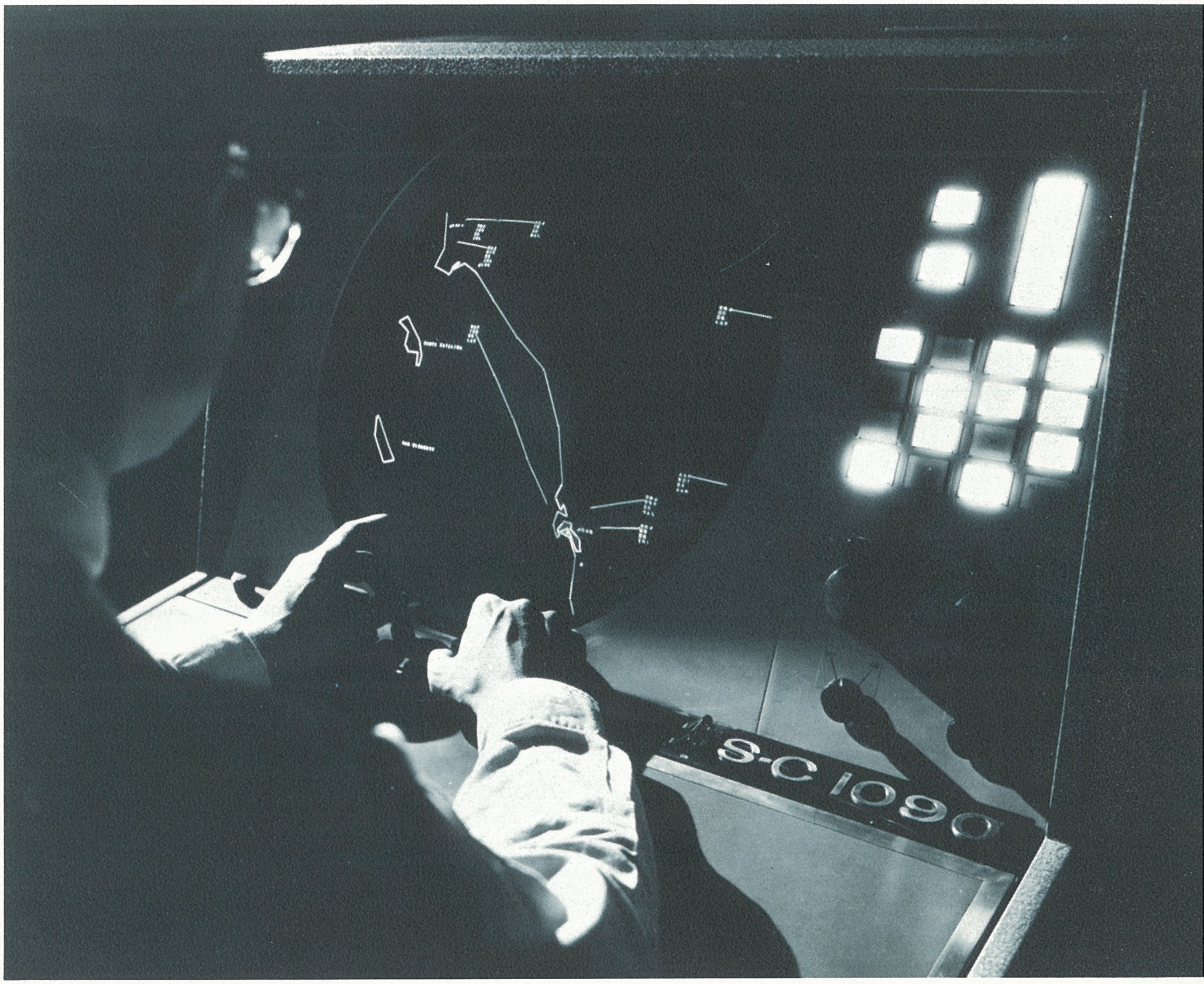
All data will be analyzed to determine how well particular structures met original design objectives, and will be compared to previous estimates of crashworthiness potential. Final results of this study, describing the various design philosophies and concepts with advantages and disadvantages of each, and an evaluation of the costs involved versus the benefits possible, will be incorporated in a report to the Federal Aviation Agency.

GENERAL DYNAMICS | CONVAIR

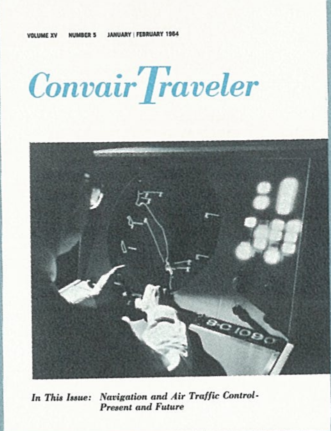
VOLUME XV NUMBER 5 JANUARY | FEBRUARY 1964

Convair Traveler

11 44



In This Issue: *Navigation and Air Traffic Control-*
Present and Future



VOLUME XV NUMBER 5 JANUARY | FEBRUARY 1964

Convair Traveler

In This Issue: Navigation and Air Traffic Control-Present and Future

OUR COVER

By way of preparation for laying out this issue, Artist Tommy Thompson underwent some extended briefing on pulse timing, binary theory, code interlace, and related topics. It reminded him of the little girl's book that, she reported, "told me more about penguins than I want to know." Sympathetic readers who find the text slow going might just skip that part and look at Tommy's informative illustrations.

Convair Traveler

VOLUME XV NUMBER 5 JANUARY/FEBRUARY 1964

MANAGER, CUSTOMER SERVICE—**O. W. HARPER**
CHIEF ENGINEERING SERVICE—**L. J. BORDELON**
CHIEF, FIELD SERVICE—**R. W. SOMMERS**
CHIEF, SERVICE PARTS—**J. DOIG**
CHIEF, TECHNICAL PUBLICATIONS—**H. R. KENNEDY**
EDITOR—**GERTRUDE S. HUNTER**

IN THIS ISSUE

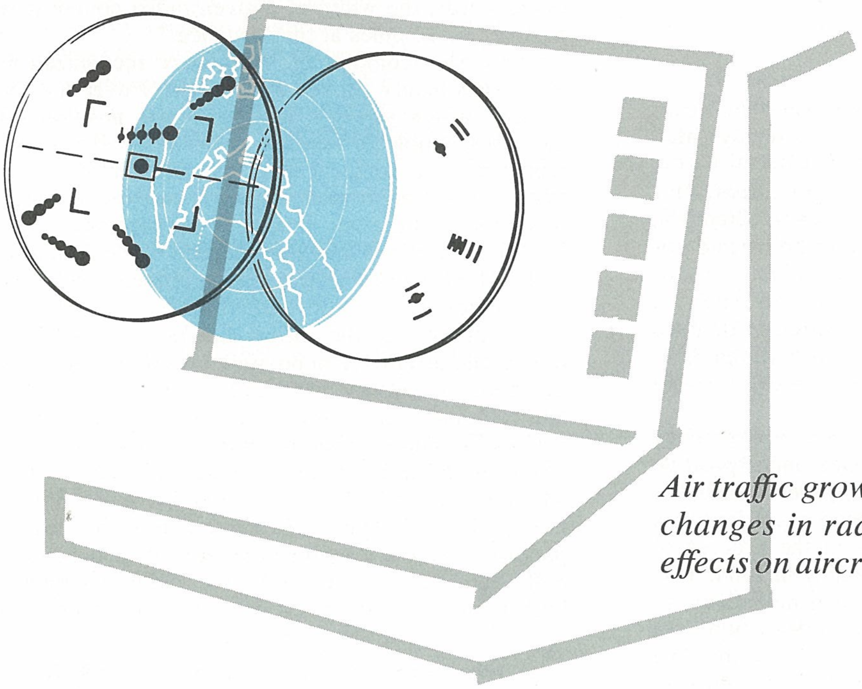
Page 3
NAVIGATION AND AIR TRAFFIC CONTROL
Present and Future
Hugh R. Smith

Page 12
FIRE AND OVERHEAT WARNING SYSTEMS
H. G. Ayer

A digest of operation and service published monthly by the Technical Publications Section of GD | Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics | Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

COPYRIGHT 1964

GENERAL DYNAMICS | CONVAIR



Air traffic growth is compelling some major changes in radar control, with consequent effects on aircraft equipment and operation.

Navigation and Air Traffic Control - Present and Future

IN THE NATIONAL AVIATION FACILITIES Experimental Center in Atlantic City, at the time this is being written, a radar specialist sits before a General Dynamics/Electronics S-C 1090 console with a 19-inch television-like screen showing a map of air traffic. A little box of letters and figures appears at one edge—an airline abbreviation, flight number, destination, and altitude. An airplane radar target, marked by a dot and a vector line, appears near the box. The box attaches itself to the dot, and the specialist watches it move across the screen until a handoff symbol appears at the other edge. He touches a button; a few seconds later the display disappears—the handoff is complete.

But it's not for real. The console is being fed a flight plan, and possibly a flight or simulated emergency situation, by a 7090 computer. This is just a test pattern.

Three years ago, the Traveler, in describing navigation equipment aboard the Convair 880/990 aircraft, noted that there would be more to install later. The trade press and forward-looking engineers agreed that more electronic marvels were at hand; precision altimeters, devices to warn a pilot when he was nearing a collision with a mountain or another airplane; electronic cockpit maps to show a pilot where he is at a glance. Just around the corner, it appeared at that time, was an automatic ground-air-ground communications system that would keep a constant log of the flight's identity, position, and altitude. It would relay flight instructions and piloting information at the touch of a button, and probably would be hooked up with a ground communications network that would automatically follow a flight across the country with hardly a word spoken.

It has been a long tomorrow, so to speak. Proximity radars and reliable radio altimeters have proved thorny electronic problems. Surveillance radar remains, for the most part, a scattering of darkened rooms crowded with more and more PPI scopes, manned by harried operators who by a concentrated effort of imagination convert cryptic symbols on their screens into a 3-D mental picture of aircraft flying in their areas. Pilots still talk themselves from tower to tower around the world.

The navigation and electronic equipment that went out on the first 880 is still entirely adequate today. Nevertheless, it is true that there are changes coming up, some soon and some several years away. Without attempting to say exactly when, we may have a look at some developments in aircraft electronics that are fairly certain to come about within the next few years, and note how the Convair jet airliners will have to be adapted to them.

Navigation Equipment Requirements

Main lines of the planned development were laid down in the "Project Beacon Report," more formally titled "Report of the Task Force on Air Traffic Control." This was a set of recommendations by a presidentially-appointed committee of transport engineers, scientists, and military men, outlining a program to be carried out through 1975. Some months later a voluminous master plan was released by the Federal Aviation Agency, the first edition of a "Design for the National Airspace Utilization System." Both reports are too comprehensive even to be summarized here; however, some points may be noted.

One recommendation now in the process of being carried out is the extension of airspace under positive control. During the past year, practically the whole of the high-altitude continental area has been placed in this category. The 24,000-ft minimum is in the process of being lowered soon to 18,000 ft, probably in 1964. This will be lowered to 14,500 ft (except over mountains) to 8,000 ft in high-use airways, to downwind-leg altitudes in busy terminal areas, and down to the surface within five miles of the terminal itself. These changes will not directly affect 880/990 electronic equipment requirements, but many piston-engine aircraft, including Convair-Liners, are going to require some additional items.

On air navigation, Project Beacon decided: "Our presently planned VORTAC navigation system, when the DME system is completed, appears to be adequate for the volume of traffic expected over most of our airways in the next 10 to 15 years." That, to the pilot, means among other things this: not much help coming for navigation from the cockpit. A corollary finding is that DMET (Distance Measuring Equipment—Tacan) is going to be a practical necessity for all airliners, as well as a present official requirement for aircraft operating at high altitudes.

By way of elaborating on the pilot's feelings about traffic control, he unquestioningly recognizes the necessity for radar control and appreciates the help that controllers give. Nevertheless, the chief pilot is a captain of a ship, with a captain's final responsibility, including the prerogative of overriding ground instructions if he deems it necessary. He would like to have every aid possible at his own command, at least for a double check, and not have to depend entirely on a ground-borne information loop of fallible equipment and human beings. The Project Beacon report, however, noting the limitations of VORTAC and the present lack of practical collision avoidance and proximity warning devices, states, "In the meantime, our dependence will have to be on 'see and be seen' and positive traffic control from the ground."

The limitations of the VORTAC system were set forth in the report as follows: ". . . On a level site free from reflecting objects . . . VOR . . . provides bearing accurate to about ±2° . . . Power lines, metal stacks and towers, and major terrain features [cause] scalloping . . . The course appears to swing back and forth by as much as 2°, in addition to the normal instrumental and installation errors . . . at a distance of 100 nautical miles an error of ±4° in bearing amounts to ±7 nautical miles. In other words, the width of a given radial course may be as much as 14 miles at that distance."

These shortcomings of VOR were recognized when VOR was finally chosen by the ICAO over the Decca system, which yields a more accurate position but is more susceptible to weather interference. However, the report notes a compensating feature of VORTAC: "A system based upon multiple DME measurements giving nearly simultaneous distance measurements to two VORTAC stations has been studied . . . Positional accuracies of ±1 nautical mile are easily obtained, ±.5 nautical mile is possible, and in certain areas . . . ±.2 nautical mile is possible in the critical direction." This hints at a future role of DMET in possibly lowering lateral separation requirements in controlled airspace—both en route and terminal area. Convair 880/990 aircraft have provisions for dual installation; many already have it.

Though DMET is not yet required for flight at altitudes where propeller craft operate, pilots have found it highly useful as a check on VOR and in approach and holding patterns. There is also one other advantage in being presently equipped with DMET—the lower minimums for longitudinal separation. Fig. 1 shows this in detail. It is

Aircraft without DME vs both aircraft equipped with DME

	MINIMUM SEPARATION	
	WITHOUT DME (flying time)	**WITH DME (miles)**
Below 24,000 ft, after takeoff or en route:		
Preceding aircraft 44 kts faster	3 min	5 mi
Preceding aircraft 22 kts faster	5 min	5 mi
Other conditions	10 min	20 mi
Above 24,000 en route:		
Preceding aircraft 22 kts faster	5 min	10 mi
Other conditions	10 min	20 mi
Crossing courses, same altitude:		
Preceding aircraft 44 kts faster	10 min	5 mi
Preceding aircraft 22 kts faster	10 min	10 mi
Other conditions	10 min	20 mi
Crossing altitudes, same or converging courses:		
Below 24,000 ft, 2000 ft vertical separation, within 10 min of report of following aircraft	5 min	10 mi
Other conditions	10 min	
Above 24,000 ft, 2000/4000 ft vertical separation, within 10 min of report of following aircraft	5 min	
Other conditions	10 min	
Crossing altitudes, opposite courses:		
After estimated passing time	10 min	None after DME reports show passing
After position reports show passing:		
Below 24,000 ft	None	
Above 24,000 ft	5 min	
Takeoff on diverging courses:		
Diverging immediately	1 min	3 mi if diverging within 13 mi
Diverging after 5 min	2 min	
Climbing through preceding aircraft altitude	3 min	5 mi

Figure 1. Comparison of longitudinal separation minimums (non-radar).

possible that full use of dual DMET may eventually require addition of an airborne computer.

Jet transport airborne equipment is well out ahead of most ground facilities in one respect. The FAA several years ago notified the industry that VHF communications and navigation receiver-transmitters would be required to reduce channel spacing from 100 kc to 50 kc, thereby doubling the channels available. All 880/990 aircraft are so equipped, and await only equivalent implementation of ground equipment.

Another recommendation of Project Beacon under intensive development is all-weather landing capability. There will come a time when zero/zero landing is possible, but it evidently will not be soon. Precision ILS localizer and glide slope beams, accurate altitude-above-terrain data, automatic flare control and instrument presentation are still under study. It now appears that basic changes in both ground and airborne equipment may be necessary. It is possible that present ILS beam accuracy and range can be improved, so that some current visibility minimums can be lowered with the present airborne equipment.

Though not under the heading of navigational equipment, it may be noted that the FAA has proposed and discussed a requirement for commercial transports to carry a recorder that monitors cockpit conversation. ARINC specifications are now in submittal stage. Most jet aircraft today carry flight recorders that register altitude, airspeed, heading, and vertical acceleration, by recording with stylus marks on metal foil. If the cockpit monitor is required, it will most probably be an additional installation.

Radar Air Traffic Control - Present

Since ground radar control is going to be the principal means of regulating the ever-growing number of aircraft, let us have a look at it. There are two main types of facilities: ASR (Airport Surveillance Radar) and ARSR (Air Route Surveillance Radar). ASR covers terminal areas, with a maximum range of about 50 miles; ARSR monitors en route flights, and range extends to 200 miles. In some areas, signals from other radar installations are "remoted" into the ARSR facility (an ARTCC, Air Route Traffic Control Center), so that one ARTCC area may extend over several hundred miles.

Another classification breaks terminal facilities down into three kinds: IFR rooms, FAA-built and operated; RAPCON's (Radar Approach Control), which are Air Force facilities with FAA personnel operating Air Force ASR equipment; and RATCC's (Radar Air Traffic Control Centers), Navy facilities with FAA personnel operating Navy ASR equipment. The equipment is by no means standard, even among facilities of one type. A RATCC radar controller transferring to RAPCON would require retraining, much as a DC-8 pilot needs additional training to fly an 880.

A second type of route surveillance facility was recently activated—a SAGE center first established as a station in the network that would warn of unidentified aircraft approaching United States borders. This is apparently an experimental development to evaluate the possibility of using other SAGE facilities in commercial aircraft control.

The pilot of a commercial jet goes under ASR control almost the instant he is airborne. The pilot is "vectored" out of the terminal area; that is, given very explicit instructions on how far to climb, what VOR radial to follow, when to turn off, and what altitude to fly. He may be "tunneled" out of the area at a specific altitude, sometimes in a pattern that can only be described as "crazy-quilt," and authorized to climb to cruise altitude only when reasonably clear of terminal area traffic. Usually, within five to ten minutes he will be "handed off" to another facility. This entails a conversation between the radar facilities, instructions to the pilot, change of radio frequency, an altitude and sometimes a position report by the pilot to the second facility, and often further conversation as the second controller identifies which blip on his scope represents the particular aircraft.

From then on, at hundred-mile intervals or less, the pilot will check in at successive reporting points and be handed off from one facility to another until he is finally vectored in at his destination. Over most domestic routes he will be followed by long-range ARSR, and he will cross the scopes of a number of local ASR's who may not be concerned with directing his flight but who must know enough about him to be sure he is not their concern. All this, of course, the pilots must attend to in addition to flying the airplane and doing their own navigating.

Around Chicago or Los Angeles, a 16-inch scope will show a lot of aircraft targets—more than could be sorted out without the aid of the ATC transponder. Of the changes slated to be made in airborne equipment soon, those to the ATC transponder are of most significance in several respects: most expensive, for both operator and the FAA; most complex electronically; and most potentially useful in handling the mounting load in air traffic control.

The radar-transponder system (ATCRBS, Air Traffic Control Radar Beacon System) is also a fascinating study to anyone with a curiosity about how things work. First let us examine the present system, airborne and ground, and then take up what the system will be like in the future.

The transponder is a radar beacon; it answers a radar query from the ground, reinforcing the visible spot on the radarscope that marks the airplane. It also conveys coded information in the answer. The pilot's transponder control panel, besides the on-off and sensitivity switches, has a mode switch with four positions—A, B, C, and D, at present always set on A (in commercial aircraft in this country); two wheels or multiple choice switches with eight positions, numbered from 0 to 7, to set the code to be conveyed; and a button labelled IDENT.

The ground interrogation signal is transmitted on 1030 megacycles, the response from the aircraft on 1090 mc. The ground station interrogates in modes; the transponder replies in codes. Both signals are pulse patterns (Fig. 2). The interrogation is a pulse pair; an 8-microsecond spacing determines that the interrogation is in Mode A. The reply is a train of pulses, consisting of at least a pulse pair (the framing pulses) plus other pulses as determined by the code set by the pilot and the IDENT button.

So far as the pilot is concerned, his responsibility with

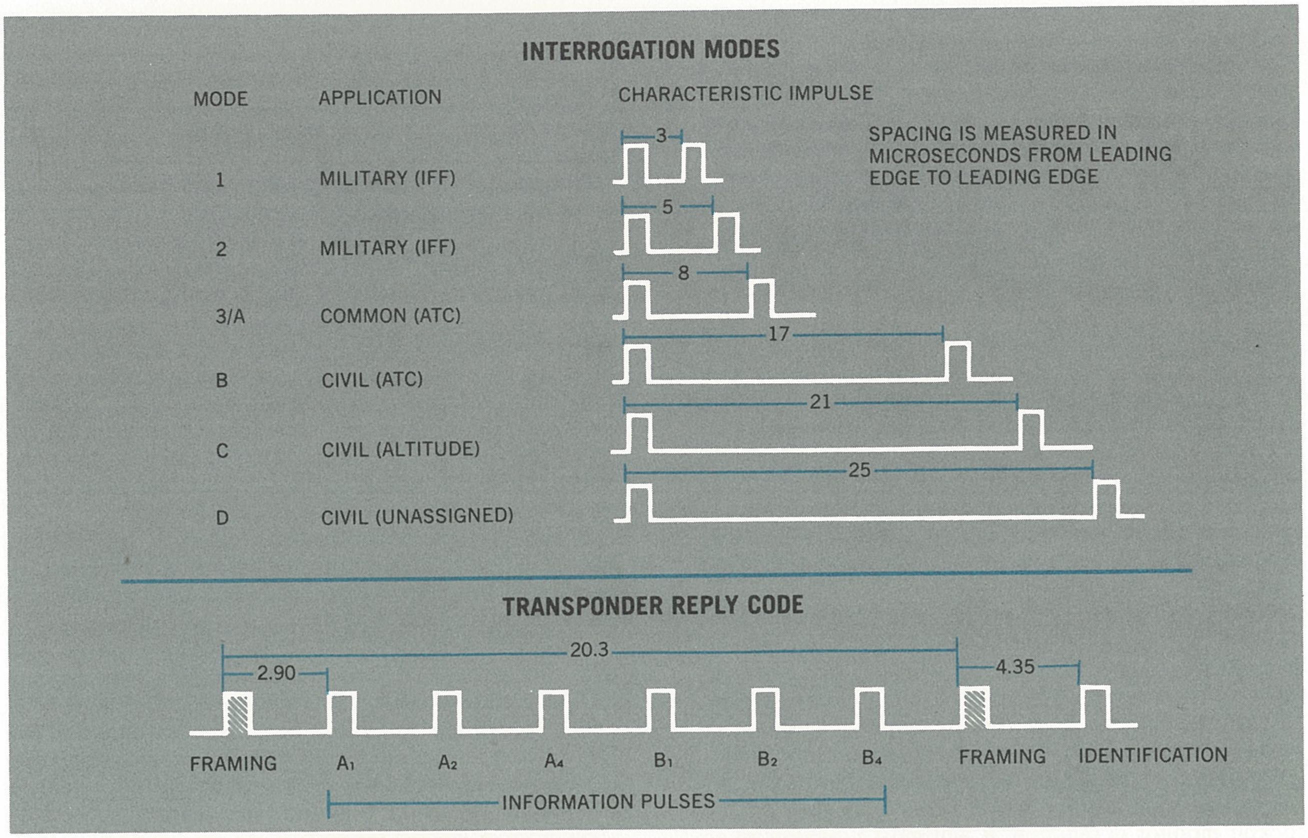


Figure 2. Present interrogation modes and reply codes.

the transponder is merely to turn it on at takeoff, set the code as instructed, and press the IDENT button or change the code when requested to do so.

At the other end of the exchange—the radar room of an airport or route surveillance facility—we might review a little basic radar by way of explaining what the radar controller actually sees.

Like the picture on a television screen, the return on a radar cathode ray tube (CRT) is generated by a single spot of light, made by a thin electron beam. On a television CRT, the beam traverses the phosphor screen horizontally, moving downward each traverse, covering the area 30 times a second to generate a picture. On the radar CRT, the beam moves outward from the center at a rate of a mile (on the scope) every 10.75 microseconds, half the speed of light. The trace left by the beam shows on a scope as a dim radial sweep line.

A radar pulse is transmitted from the antenna as the beam starts its radial motion, travels to an object at the speed of light, and is reflected. The reflected signal is received and amplified to augment the sweep beam and brighten the scope at that spot. The distance of the bright spot from the sweep beam origin point is thus a measure of distance of the object from the antenna. The radar pulse transmitted is highly directional, and the antenna constantly revolves. A synchro revolves the scope sweep mechanism with the antenna, thus placing the object in the proper azimuth from the center of the scope.

This primary return is separate and distinct from the transponder response, transmitted on different frequencies and often on different frequency levels. An airplane—any airplane—appears as an oval blip, its distinctness varying with the size of the aircraft and its distance from the facility (and also on augmentation of the signal by a transponder). Surveillance radar originally could not distinguish between objects at different altitudes. A water-tower ten miles away would show an almost identical blip; an airplane flying over the tower would be distinguishable only as it moved on successive sweep rotations. Radar echoes from city skylines, mountains, or precipitation might make it impossible to see the airplane blip at all. There is, however, auxiliary equipment at most facilities that can cancel stationary targets from the scope, and attenuate raindrop echoes, to eliminate much clutter.

So much for primary radar. The transponder interrogation is transmitted from a separate antenna mounted on the primary radar reflector. The reply, a pulse train 24.65 microseconds long, always contains the framing pulses (Fig. 2); the other pulses are according to the pilot's setting of the code. The coding system (Fig. 3) is indicated, with the numerical values shown. With six code pulses, the number of on-off combinations is 2^6, or 64 possible codes. For coding purposes, the six pulses are divided into two groups of three each. There being eight on-off combinations of three, each group is assigned eight numbers (0 through 7). Thus the 64 codes are numbered from 00 through 77 (no 8's or 9's being available).

This pattern of pulses is actually reproduced pictorially on the primary radar scope. The signal is superimposed

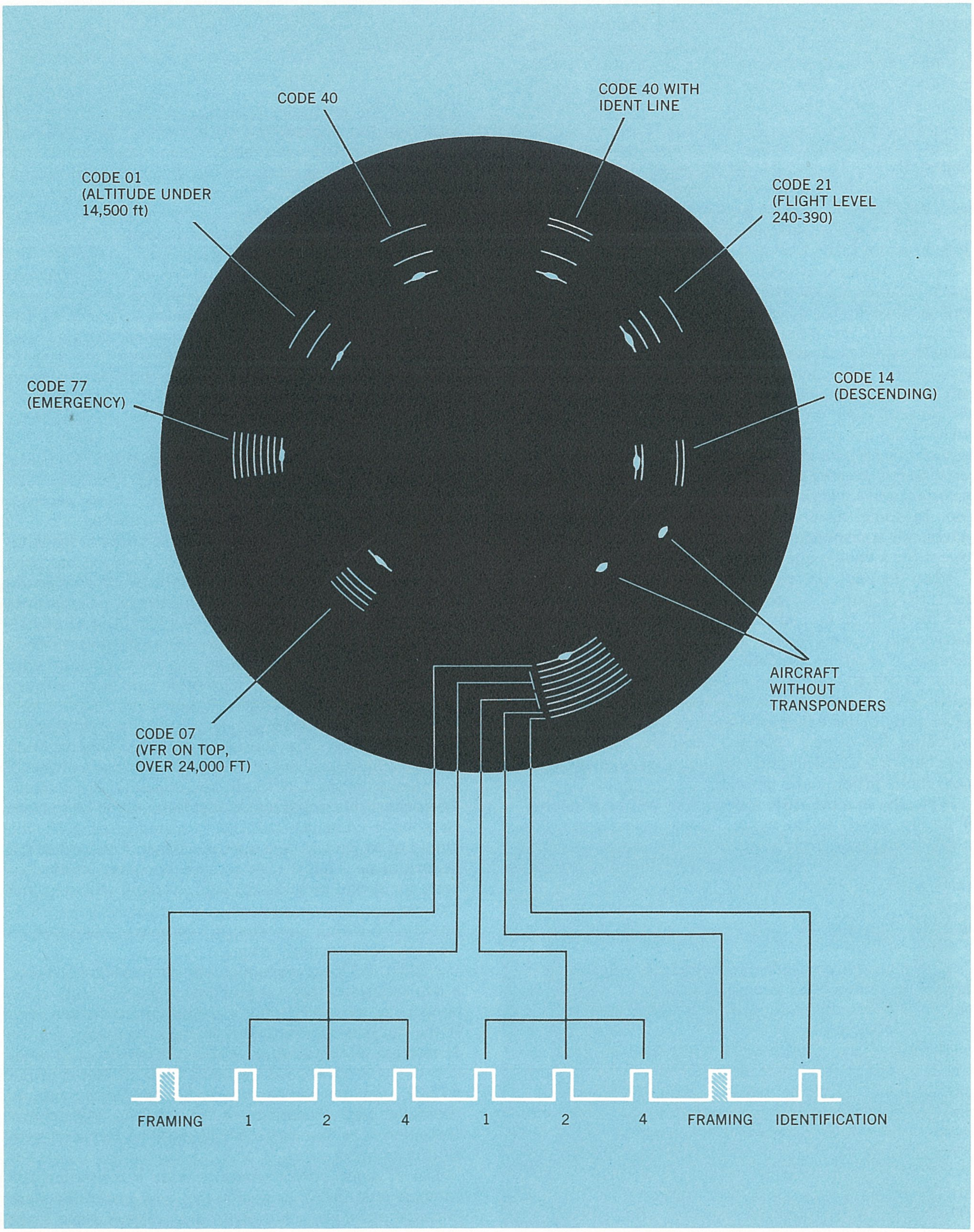

CODE 40
CODE 40 WITH IDENT LINE
CODE 01 (ALTITUDE UNDER 14,500 ft)
CODE 21 (FLIGHT LEVEL 240-390)
CODE 77 (EMERGENCY)
CODE 14 (DESCENDING)
AIRCRAFT WITHOUT TRANSPONDERS
CODE 07 (VFR ON TOP, OVER 24,000 FT)
FRAMING
1
2
4
1
2
4
FRAMING
IDENTIFICATION

Figure 3. Typical present transponder codes and how they appear on ATC radarscopes. Pulse patterns appear as slashes radially outward from the primary radar return.

on the sweep beam, so as to generate a series of lines in juxtaposition to the radar blip. The first framing pulse is a short arc passing through, or just outside of, the primary blip. The second framing pulse is an arc 1.6 miles radially outward. The code pulses transmitted appear between, spaced according to their time scheduling in the pulse train.

The Airmen's Guide notes ten codes for standard use. Codes 01, 11, 21, and 31, for example, denote aircraft assigned altitudes within certain ranges; 06 and 07 are for VFR flights, 77 for emergency. The patterns made by these codes show an obvious reason for choosing them—they are more easily read at a glance.

Equally obvious, to a visitor in a radar room, is the fact that it requires a good deal of training and experience, as well as good eyesight, to read the code at a glance. In centers with the most sophisticated equipment, an azimuth-range electronic gate, or a "light gun" resembling a toy pistol, can be aimed at the code lines and the code read on a digital readout panel. But in by far the most of the present ASR rooms, the controller makes his best guess at the line spacing, and checks by setting the code on his own equipment and pressing a "decode" button to see if he has guessed right. If he has, the display changes in certain ways, varying with the types of ground installation. In some, all codes disappear except the one; in others, all transponder replies reduce to a single line except for a double line for the code selected.

When the pilot, on request from the controller, pushes the IDENT button on his panel, the transponder transmits for 15 to 20 seconds the "identification" pulse after the second framing pulse. This is not a pulse pattern peculiar to a certain airplane; it merely enables the controller to tell which blip on his scope is transmitting the pulse. When the full code is displayed, the IDENT pulse is just an extra line beyond the framing pulse; with decode switching, the display changes, becoming an extra line, wide bar, or a doubled train, depending on type of equipment (both airborne and ground).

Typically, in most ASR rooms there will be a number of scopes slaved to the master scope, with a controller at each assigned a certain sector. Within a busy terminal area, the scopes become even more cluttered with code trains added to primary returns. A visitor cannot but be impressed with the skill required, and displayed, in mapping and managing air traffic by interpreting the jumble of dots and lines on the present PPI.

A terminal area controller is theoretically able to handle safely a maximum of 15 aircraft an hour in his sector. He may have to handle more; but even at that rate, he has only four minutes to devote to each one. That isn't very long to examine a telephoned or teletyped flight plan, tie it in his mind to a certain target on the scope, get the pilot's altitude from him and keep track of it by radio, fit him into the traffic pattern and possibly vector him into and out of a holding pattern into an airport.

The New York terminal area is reported already saturated an average four hours a day. Project Beacon estimated a 44% increase in total flying by 1975, but a 300% increase in traffic under positive—that is, radar—control. The situation around all major terminals is rapidly worsening, and even the busier en route airways are expected to reach overload within the next few years.

Air Traffic Control - Future

Help for the controller is coming; a glimpse of the 1975 look was the introduction to this article. But more immediate help will come before then, when commercial aircraft—and most other aircraft flying in positive controlled airspace—are equipped with transponders with altitude-reporting capability.

Transponders factory-installed in most 880/990 aircraft conformed to ARINC Characteristic 532B. Besides being able to reply in a choice of 64 codes, they include circuitry enabling them to reply with a 13-pulse code, spaced at 1.45 microseconds instead of 2.90 (Fig. 4). The pins are there; all that would be needed, the plan was, would be a control panel to set the code and perhaps another module, along with whatever altitude transducer and encoder was decided upon.

In ARINC Characteristic 532C, however, some other improvements were specified for aircraft like the 880/990 transports. These requirements include three-pulse side-lobe suppression, short and long pulse rejection, echo suppression and external suppression. These were determined to be necessary for reliable operation.

The principal reason for adding the codes is for automatic altitude reporting. Interrogation Mode C has been reserved for this. When the transponder interrogates in Mode C, or in Modes A and C in a time-share or interlace pattern, its reply will be a code giving the airplane's altitude in hundreds of feet. Use of the present Mode C switch on the pilot's panel would not be necessary; with the mode switch at A, the transponder will have circuitry to reply to Mode C with the altitude code.

The electronic means for doing this have been fairly well worked out. The altitude signal can come from an aneroid transducer, but in 880/990 aircraft will probably be taken from the KIFIS air data computer by synchro. To convert this signal into digital form, it will be fed into an altitude computer (ARINC Characteristic 549), the output of which will be a digitized signal. This will be fed in turn to an ARINC 548 altitude encoder, which converts the digital signal into a pulse train for triggering the transponder. The encoder may be integral with the transponder, in which case the transponder is labelled an ARINC 532D configuration.

ARINC 532D transponders are now available. There is a question whether it is practical to modify 532B transponders, or more advisable to go directly to the new unit. If the 532B is modified, the changes necessary will be 1) internal modification to 532C configuration; 2) addition of the ARINC 548 encoder; 3) modification of the KIFIS computer unit to provide a signal for the altitude computer; and 4) addition of the ARINC 549 altitude computer. The last two changes will be required with all transponders.

The 13 code pulses would provide a theoretical 2^{13} combinations (8192, or double that with use of the identification pulse also). However, the center X pulse is not planned for use, and Mode C, rather than using all 4096 combinations of 12 pulses, will divide them into three four-pulse groups, each group representing one decimal

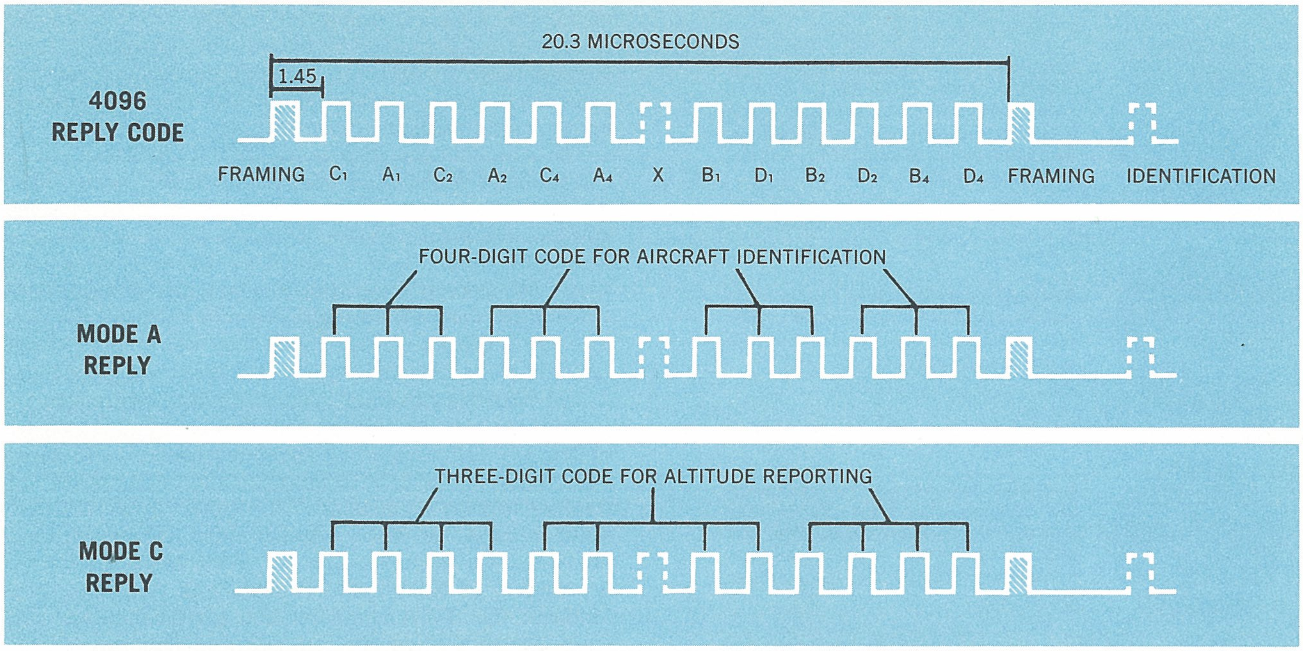


Figure 4. Schematic diagram of code replies in Modes A and C.

digit. This will enable reporting altitude in 100-ft increments over a 100,000-ft range. In Mode A, the 4096 codes will provide a capability for aircraft identification.

New ground equipment, or at least major overhaul of any presently in use, will be required to decode the transponder signals. The present code display on the PPI is obviously inadequate to yield a practical readout of a 12-pulse coded decimal number. There are several CRT's that provide alphanumeric readouts. One, the General Dynamics/Electronics Charactron® tube, is the CRT mentioned at the beginning of this article as being utilized in the NAFEC test program. Since it is typical in many respects, and is in use today in the SAGE system, it is worth a paragraph of description.

The Charactron utilizes an electron gun that focuses its beam through a tiny stencil containing a matrix of letters, numbers, and symbols. "Tiny" is hardly adequate to describe the stencil; the letters in the standard 64-character matrix are only .005 inch high, with line thicknesses less than .0005 inch; the entire matrix is less than 1/16 inch square. The shaped beam is deflected electronically to place the character on the screen at the proper position. Speed of operation is rather incredible; display rates of 50,000 characters per second are possible. A printer, using the Charactron shaped beam on electrostatic paper, can print up to 5,000 words a minute.

Other similar CRT's have guns that move the beam to trace the character on the tube face, or use dot patterns. Whatever the type eventually procured, the alphanumeric gun will probably be an additional element in the display CRT.

The controller's video display will be the bright screen type, in which radar signals are converted for use in a television-type scan conversion CRT. The display will include "raw video"—radar targets—and a video map, as do the bright displays in some facilities now.

The Mode A 12-pulse code will be divided into four three-pulse groups and converted to digital form using numbers 0 through 7. When the system is fully implemented, the pilot's clearance for the flight will assign him a four-figure code to set on his transponder, which will identify his aircraft throughout the flight. The controller, using a keyboard at his panel, can associate with this code an alphanumeric identification—probably the airline abbreviation and flight number—and the Mode C return, interlaced with Mode A, will supply the three-digit figure for altitude. A target position decoder places these two returns beside the proper target.

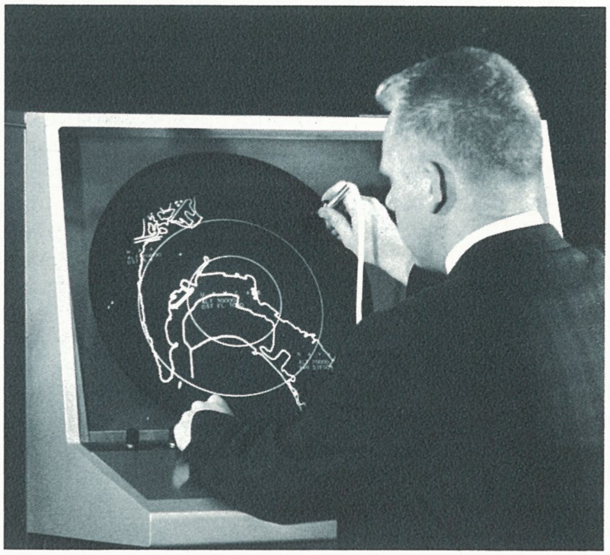
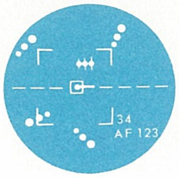
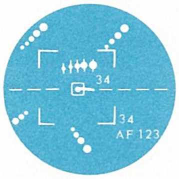


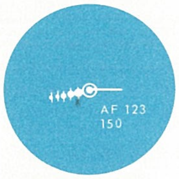
Figure 5. The GD/Electronics Charactron® is a typical CRT for displaying alphanumeric information.



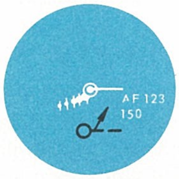
Computer alerts controller that AF 123, assigned beacon code 34, is about to enter the system and requires track initiation. Partial route display shown. Rectangle shows area in which aircraft return is expected.



Same as before but more history information available on radar returns. Code call-up by computer on beacon return shows it to be code 34.



Controller has completed identification and initiates radar track. Superfluous information has been erased from display. Controller has called up altitude information (15,000 ft). No conflicts are shown.



Track position automatically updated.

Figure 6. This is probable appearance of the computer-controlled display, and how it will work. In less sophisticated centers, tracking will be similar but initiated manually rather than by computer.

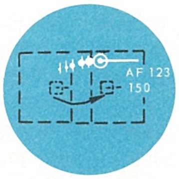
This much will be common to all ASR facilities. Also, the controller will have a video handoff subsystem that will permit positive identification of the target being handed off, eliminating the conversation between facilities now necessary. All communication with the pilot, however, will still be by voice. The pilot will still contact radar departure control at takeoff, be told when and to what communications frequency he is handed off, tune his VHF set accordingly, and report to the next facility. But he no longer will have to furnish a full report on position and altitude, and worry about establishing "radar contact." On routine flights, the conversations will be brief.

At ARTCC centers, and at 10 to 15 major terminal area control facilities, there will be a great deal more to the system. The computer will come into its own; perhaps some off-the-shelf computer units, perhaps elaborate special equipment tailored to the system. Flight plans will be computer-processed before the first clearance is granted; terminal area controllers will rely on it for sequence schedules of arriving and departing aircraft and for constant monitoring of the flight. Computers will vector the airplane, assign altitudes, digest the flight plan, extrapolate it, check it continuously against the flight, watch the weather, supply NOTAMS, warn when the aircraft is off course or nearing a collision danger, and suggest ways to avoid trouble. Pilots used to call the autopilot George; the fully automated ATCRBS could be appropriately designated Big Brother.

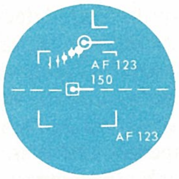
The alphanumeric display on the CRT will include an extrapolated flight plan position, possibly some flight plan data, and controls to update the computer when the extrapolated position varies from the actual or when the flight plan is changed. Controllers working in sectors where all aircraft have transponders may remove raw video from their display altogether to clean up the picture. On a tabular display panel, they will be able to call up flight plans from the computer, receive warnings from it, and transmit messages to it or to other controllers.

Some high-speed printer like that mentioned will be necessary for readout of the computer-stored data. NOTAMS will be printed automatically, flight plans and weather reports on demand. The Project Beacon report noted a need for more weather data and more rapid dissemination of it. Weather for flying being a joint responsibility of the Weather Bureau and the FAA, it is probable that FAA computer and printer facilities will enter into general weather analysis and reporting.

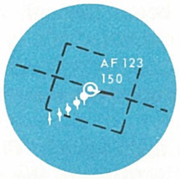
Radar position has advanced beyond extrapolated flight plan prescribed limit. Computer automatically updates flight plan, calculates new ETA and probes for possible conflict. Flight plan position (in black) is not displayed.



Radar position has gone beyond prescribed lateral limit of flight plan. Automatic update inhibited; flight plan position shown. Conflict probe, using radar position as intermediate fix, shows no conflicts.



Controller talks to pilot to verify intent, modifies flight plan route using radar position as intermediate fix. Computer then automatically updates flight plan. Flight plan position (in black) not on scope.



Controller is alerted that a radar handoff action is required. Transfer of control will be given over to control team 2.

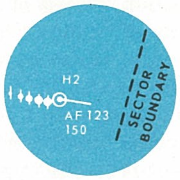


Figure 7. At major centers, computer will compare radar position with the extrapolated flight plan, give warning when discrepancies occur, receive inputs from the controller, and update flight plan accordingly.

The Timetable

When will all this take place? Not all at once, by any means; some of it perhaps not even by 1975. A "Design for the National Airspace Utilization System" summary, dated September 1962, sketched the timetable approximately as follows:

Computers are in present use at some facilities for flight plan processing and ETA, but without any direct hookup to radar or transponder returns. Equipment for processing Modes A and C 4096-code returns, for digital readout on a separate panel, and for conversion of transponder altitude to mean sea level where applicable, was planned to be ready for installation by 1964. Alphanumeric presentation on the PPI display would begin to be available by late 1964. This will be the basic equipment for some 200-odd radar facilities.

Project Beacon recommended mandatory altitude-reporting transponders for all aircraft over 12,500 lb gross weight, when ground equipment is ready to process the signals. A guesstimate for this date by the NBAA (National Business Aircraft Association) magazine *Skyways* was 1966 for aircraft flying above 24,000 ft, 1967 for all flight in other positive control areas, and 1968 for all IFR flight; the latter two dates depending in part on whether a low-cost (SLATE) transponder becomes available for small aircraft. But the requirement will certainly apply to all commercial passenger transports. Few piston-engine aircraft have transponders now; but, as with DMET, there will be definite advantage to pilots in having an aircraft with an altitude-reporting transponder.

Interconnection between computer and the active display control system will likely not come about until 1966. This equipment will be used only in the ARTCC's and in high-density terminal areas.

High-speed printout equipment will be added at the computer centers. The flight-number-and-altitude data will be expanded, probably to include flight plan and sequencing information, and the extrapolated flight plan position will be added, with means to update the computer storage.

The PPI will still show aircraft not equipped with fully coded identification transponders. When the controller identifies such a target, he will be able to add on his scope identification and flight plan data from the computer, attaching it to the target electronically.

These changes in ARTCC ground equipment will be added sequentially, in approximately the order in which they are described in the preceding paragraphs. Last to be added will be the tabular display subsystem. This implements the planning functions of the computer—analysis of flow control data, solutions to generalized traffic problems such as overload of a facility or airway, and remoting equipment to transmit the data to towers and other facilities.

Development of computer-centered control, even according to the timetable hoped for a year ago, is a program for several years from now on well into the 1970's. In fact, the FAA has been working on the system for seven or eight years already, and no one will be surprised if it still progresses slower than planned. The timetable is highly tentative. It does not depend on electronic and data-processing breakthrough; but attaining the necessary precision and reliability is taxing the ingenuity of the developers.

There remains one less than optimum aspect of the system, already mentioned; the pilot will be "flying blind," in a sense. If the controller's picture of the traffic in the sector, and the information available from the computer, could be remoted automatically to the cockpit, it would be a powerful aid in piloting. The time, however, is not yet. Experiments in that direction are being made, here and abroad. Air Force experience with two-way data link indicates that some such equipment is within the realm of the possible. But the complexity, expense, and the sheer volume and weight of the presently available equipment make it impractical for commercial traffic.

For the time being—for the next ten years at least—the pilot is going to have to fly by what the man tells him, over the radio. The present solution to the air traffic problem is analogous to the opening of a freeway: The traffic will be no lighter. Finding a way through it will be no easier, nor will the task of managing it, even from the most up-to-date computerized headquarters. The gains will be the negative one of not being swamped in a constant traffic jam, and the positive gains in time, in efficiency, and in the safety that can be salvaged from the threat of overcrowding.

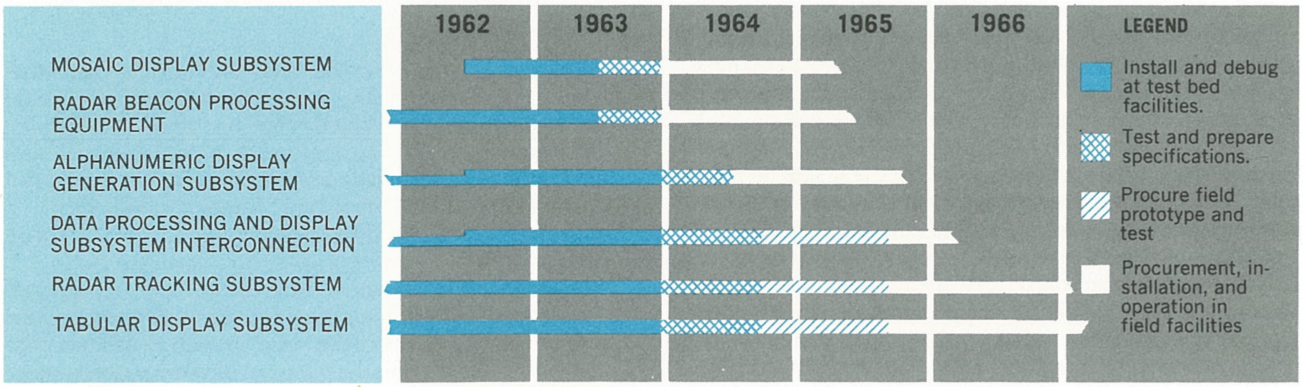
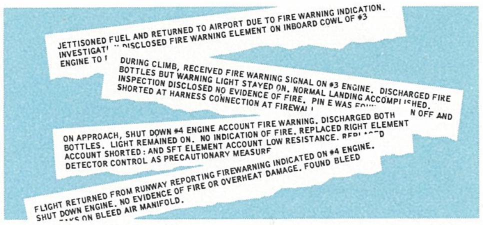


Figure 8. Proposed (1962) progressive implementation plan for the ATC subsystem.

Fire and Overheat Warning Systems

Approximately 40 percent of all airline inflight shutdowns are due to false fire warnings



JETTISONED FUEL AND RETURNED TO AIRPORT DUE TO FIRE WARNING INDICATION.
INVESTIGAT DISCLOSED FIRE WARNING ELEMENT ON INBOARD COWL OF #3
ENGINE TO

DURING CLIMB, RECEIVED FIRE WARNING SIGNAL ON #3 ENGINE. DISCHARGED FIRE
BOTTLES BUT WARNING LIGHT STAYED ON. NORMAL LANDING ACCOMPLISHED.
INSPECTION DISCLOSED NO EVIDENCE OF FIRE. PIN E WAS
SHORTED AT HARNESS CONNECTION AT FIREWAL
N OFF AND

ON APPROACH, SHUT DOWN #4 ENGINE ACCOUNT FIRE WARNING. DISCHARGED BOTH
BOTTLES. LIGHT REMAINED ON. NO INDICATION OF FIRE. REPLACED RIGHT ELEMENT
ACCOUNT SHORTED: AND SFT ELEMENT ACCOUNT LOW RESISTANCE.
DETECTOR CONTROL AS PRECAUTIONARY MEASURE

FLIGHT RETURNED FROM RUNWAY REPORTING FIREWARNING INDICATED ON #4 ENGINE.
SHUT DOWN ENGINE. NO EVIDENCE OF FIRE OR OVERHEAT DAMAGE. FOUND BLEED
ON BLEED AIR MANIFOLD.

Fire and overheat warnings are—more often than not—false alarms, as indicated by the typical incidents quoted from ATA Mechanical Reliability Reports. Nevertheless, these incidents necessitate such emergency actions as activating the fire extinguisher system, aborting takeoff, interrupting flight, and dumping fuel. These nuisance alarms are costly to the airline and annoying to delayed passengers.

A brief review of the fire warning system and analyses of the causes of nuisance alarms may assist operators in overcoming problems currently being experienced by all operators of jet aircraft.

Fire and overheat detection and warning systems are installed in the engine areas of all Convair jet airliners. Additionally, the Convair 990 has fire detection and protection in the main wheel wells. The warning systems provide both visible and aural indications to the pilot whenever a fire or overheat condition exists. The *fire-detection* system is triggered by a fire or overheat in the forward engine compartment; the *overheat detection* system is triggered when there is an overheat condition in the aft engine compartment. Although the two systems are similar, there is a distinct difference between them. The principal difference in the two systems is that the fire detection system, set to alarm at 575°F (301.5°C) is forward of the vertical firewall in the region of flammable fluids. The overheat detection system, set to alarm at 765°F (407.2°C) is aft of the vertical firewall in the region of the combustion chambers, and is triggered by exhaust or combustion chamber leaks.

When the engine and pylon loops detect a fire or an overheat condition, the corresponding pull handle warning light will illuminate and the warning bell will sound. The lights will *flash* for overheat warning, whereas the lights will glow steadily to indicate a fire forward of the firewall. (A separate steady light indicates a fire or overheat condition in the wheel wells of the 990.) In either event, emergency procedures are immediately initiated.

Fire and overheat indications may be the result of 1) leaks in the engine bleed air system; 2) faulty wiring or incorrectly mounted hardware; 3) actual fuel-fed fires, or combustion chamber burnouts. While the first two conditions do not constitute an actual fire, they may actuate the fire warning system, necessitating immediate emergency action by the pilot. The pilot has no way of distinguishing between a false warning and a real fire unless he actually sees flames or smoke.

The bleed air manifold, which is designed for temperatures up to 867°F (464°C) at pressures up to 237 psig, supplies bleed air to perform many varied and useful functions: wing and engine anti-icing, engine starting, cabin air conditioning and pressurization, to name a few. But, if engine bleed air at these high temperatures and pressures should leak, an area can become overheated in a short time, activating the engine fire warning system for that engine.

To eliminate delays of this type, bleed air manifolds and ducts should be frequently and thoroughly inspected for cracks and leaks. This check is made with cowling raised, and engine operating at IDLE power. Air leaks can be felt by cautiously moving the hand around the manifold-to-engine mounting pads, and at manifold-to-duct connections. Leaking gaskets should be replaced and cracks repaired before releasing the aircraft for service.

Cracks and leaks in the manifold are often caused by incorrect installation procedures. These maintenance induced cracks can be prevented if the following recommendations are observed:

- Eliminate undesirable preloads during installation of a manifold by torquing the upper manifold engine mounting bolts first, the lower engine mounting bolts next, and the bolts at the top centerline bracket last.
- Do not force fuel heater and ejector tubes into alignment. This leads to preloading of the manifold stub takeoffs, with subsequent cracking. Re-form the tube before installation, if required.
- Be sure connecting valve and duct flanges are aligned and parallel before installing clamps.
- Whenever a manifold is replaced, be sure to install *new* gaskets.
- After a few hundred hours of service, retorque mounting bolts of replacement manifold as required. Torque values are given in Chapter 75-4-0 of the Maintenance Manual.
- Install ESNA LH3417-048 nut (for 880/880M) and ESNA Z1855-048 (for 990 with the MS9034 bolts). These replacement nuts provide good accessibility and wrench clearance for the bleed air manifold installation.
- Do not reinstall locknuts that have lost their locking feature.

On earlier type aircraft, most fire warning detectors were of the thermostatic type. A good rainshower would short them, and they could often be "fixed" by blowing the water out with a strong breath of air. A sealed type next appeared; this was an improvement, but it was still prone to shorts from moisture. Running up engines in a crosswind or tailwind could trigger the sealed type connectors.

A further improvement was the thermocouple type. This unit relied on low-resistance series connections for proper operation. A broken wire, or high-resistance connection, would put this detector out of service. Since there were from six to twelve or more detectors in series, trouble shooting was time-consuming.

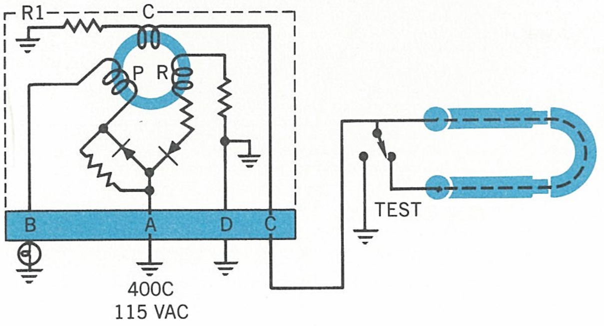


Figure 1. Fire detector schematic.

Convair jet airliners, as well as other jet aircraft and many piston types, use one of several variations of the continuous detector type. This continuous loop consists of a metal tube, a single wire in the center of the tube, and a semi-conductor material which conducts a current from the center wire to the tube, when a predetermined alarm temperature is reached.

One variation (not installed, however, on the Convair jet airliner) contains two wires in the center of the tube, which conducts from one to the other at the predetermined alarm temperature. Another variation, which was installed in some Convair 990's, requires the fire or overheat to reach two adjacent detectors to give the alarm. This prevents a single short circuit malfunction from "alarming" the system.

A thorough understanding of the operation of the fire detector may help speed up troubleshooting procedures. The system shown in figure 1 operates as follows:

One half-cycle of the 115V, 400-cycle AC power energizes power winding P, causing the magnetic domains (molecular magnets) within the core to align themselves in one direction. This constitutes a changing flux in the core, which generates a counter electromotive force (e.m.f.) in the power winding, thus limiting the flow of current. If another half-cycle of like polarity were to follow immediately, a heavy current would flow, since the magnetic domains are already aligned with the flux, and would not generate a counter e.m.f. to limit the current. This heavy current flow is prevented by reset coil R, which energizes on the second half-cycle of current. The current in the reset coil resets the magnetic domains to their original position. Resistors R2 and R3 assure that the degree of reset equals the action of power winding P during the standby condition.

A fire or overheat condition which exceeds the alarm point of the detector causes the eutectic salt between the center line and tube to conduct, with its resistance dropping to 25 ohms or less. This completes the circuit in control winding "C", reducing its impedance. The reduced impedance is reflected in the power and reset windings, reducing their impedance as well.

If the power and reset coils had equal windings, the current would remain balanced. However, the power winding has many more turns than the reset winding, so that impedance in the power winding is lowered more than in the reset winding during the alarm condition. The system is now unbalanced, and current flows in the power winding circuit, pulling in a relay and causing a light to illuminate and a bell to sound.

The dual loop system works in exactly the same way, except that both loops must be exposed to fire or overheat at the same time to give a warning. With fire and overheat isolation switches of a dual loop system in the OFF position, the center wires of each loop connect to opposite ends of the control winding of the magamp. When a flame contacts both loops, which are adjacent to each other, the impedance of the center wires to ground is lowered, connecting both ends of the control winding, giving the alarm. In order to have a false alarm, ground faults would have to occur in both loops.

If one loop is known to be faulted, the isolation switch can be thrown to the faulted loop, thereby grounding one end of the control winding. Now, when the active loop sees a low impedance, due to either a fire or a ground fault, the other end of the control winding is grounded through the low impedance path, and the alarm is given. Thus, it can be seen that with both loops functioning in the dual loop system, a ground fault can occur on one loop and no alarm is given. If the isolation switch is thrown to a faulted loop, that loop is out of the system, and the active loop functions as a conventional single-loop system; a ground fault on the active loop will then give an alarm. Shown in figure 2 is a simplified schematic of the dual loop system.

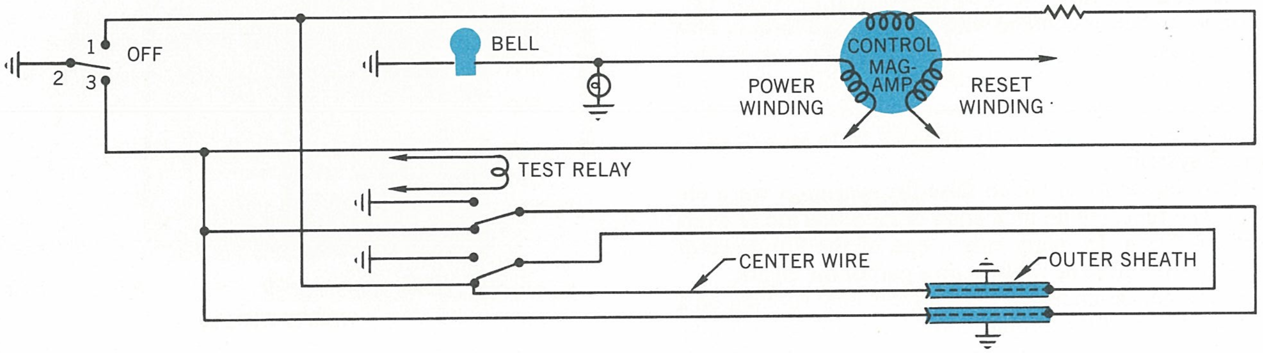


Figure 2. Simplified schematic of dual loop system.

In the discrete sensing systems, as installed on Convair jet airliners, the temperature at which the warning bell and light alarm is activated is independent of the length of the element that is heated. In a thermistor type element, as used on some other types of jet aircraft, there is a gradual change in resistance over the entire temperature range; consequently, with a control unit set to alarm at a given value of element resistance, the temperature at which the alarm is actuated depends significantly upon the length of the element heated.

Figure 3 shows the discrete system wherein the alarm is signalled at substantially the same temperature, regardless of the length of the element heated. Figure 4 illustrates the resistance values of a zone with a total length of 20 feet; the control unit is set to provide an alarm when the entire system is heated to 430°F (221.1°C). If only a one-foot length of element is exposed to elevated temperatures, note in figure 4 how no alarm would be received until the temperature had risen to 640°F (337.8°C), a value 210°F (116.7°C) above the average warning level.

The discrete sensing system as installed on Convair jet airliners is designed to provide protection against an overall general ambient rise to warn against incipient dangers. It also provides necessary protection against localized heat conditions resulting from such faults and failures as burner-can rupture, auxiliary component malfunction, bleed air duct leakage, etc.

In the discrete temperature sensing system, with elements of different alarm temperatures connected in series, each element will alarm at its fixed temperature without regard for the environmental conditions affecting any of the other elements connected in the same loop. Thus, if elements with two or more different alarm temperatures are connected in series, they will act independently. For example, a 575°F (301.5°C) element will alarm within tolerance, without regard for the fact that the ambient temperature surrounding series-connected elements 765°F and 900°F (407.2°C and 482.2°C) may vary over a range of several hundred degrees between the time the engine is started and when full warmup is achieved. This is illustrated in figure 5. Similarly, the 765° element will alarm at its temperature, within the stipulated tolerances, without regard for the environmental changes associated with the 575° and 900° elements.

The very low resistance alarm setting of the control unit, made possible by the sharp drop of element resistance at the critical temperature, protects the system against false alarms due to moisture. The connectors in the discrete system have been designed to provide a hermetic seal when assembled with the specified torque. This sealing has been demonstrated by subjecting assembled connectors to air pressure under water. A discrete type of fire detection system, therefore, provides an operating characteristic that is entirely different from an averaging type of system.

Many incidents in which false fire warnings were encountered revealed no indication of an actual fire or overheat condition. In many cases, one of the fire detector loops was found to be rubbing on a part of the engine.

It may not be immediately apparent how rubbing on a grounded part of the aircraft could cause the fire warning to actuate, inasmuch as the outer portions of the detector loops are grounded. The explanation lies in the construc-

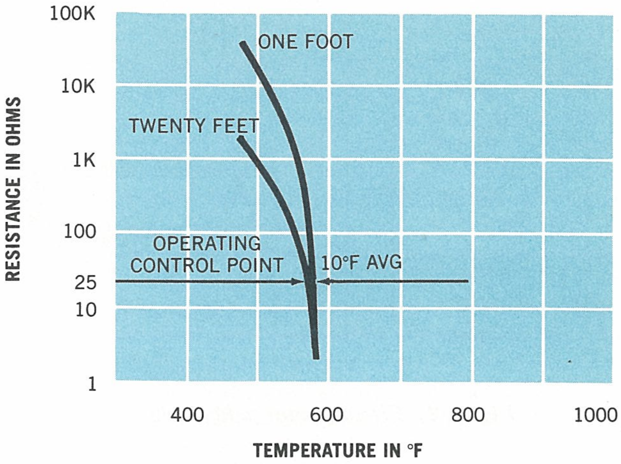


Figure 3. Resistance vs temperature for Fenwal continuous detector element.

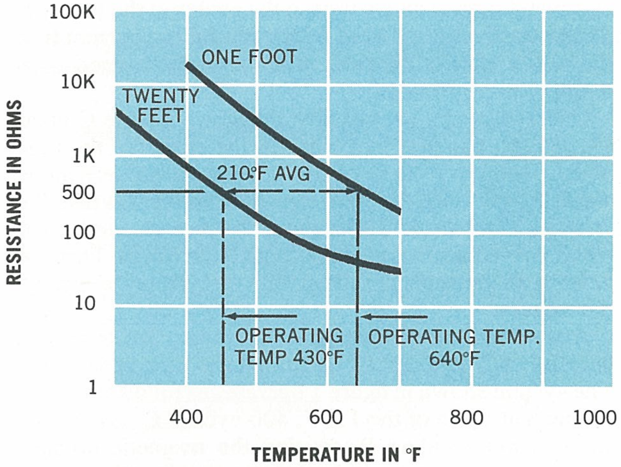


Figure 4. Resistance vs temperature for typical thermistor type continuous element.

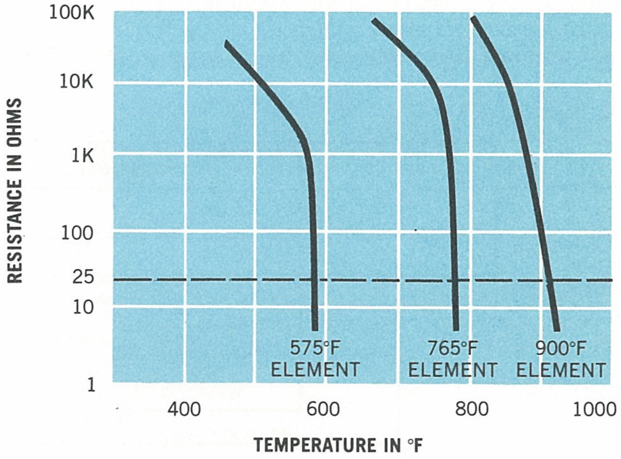


Figure 5. Resistance vs temperature characteristics for 575°F, 765°F, and 900°F sensing elements.

tion of these loops. The material between the center wire and the outer (grounded) conductor of the loop is a semiconductor (not an insulator as in most wiring). The semiconductor provides sufficient resistance between the ground and the center wire to balance the detection circuit under normal temperatures. With increasing temperature, the resistance of the semiconductor drops until the resistance across the loop is lowered sufficiently to unbalance the detection circuit and set off the fire alarm.

If the fire detection loops rub against some grounded portion of the airframe (as, for instance, parts of the engine) this can, in time, wear through the grounded outer covering on the detection loops in the semiconductor. The normal thickness of the semiconductor is then mechanically reduced, along with its resistance, until the fire warning circuit is unbalanced and a fire warning is indicated. The worn spot will also admit water, which can give a false alarm.

It is recommended that care be exercised during maintenance not to distort the fire detection loops so that they could rub on the engine or airframe, and that a visual inspection for this be conducted upon completion of maintenance. During installation, for best serviceability, a 1″ radius bend is the minimum recommended.

Troubleshooting

Since shorts in the control, power, or reset windings of the controller can cause false alarms by creating an unbalanced condition between the power and reset windings, the controller can be tested separately.

Tests of Controller. A fairly simple test for the controller is made as follows, using the portable tester illustrated in figure 6.

Standby Check: Turn switch S1 to 200 ohms, position 1. Voltage across the load resistor, 350 ohms, should not exceed 1.0 VDC.

Operating Check: Turn switch S1 to 5 ohms, position 2. Voltage across load resistor, 350 ohms, should be between 7.0 and 13.0 VDC.

Limit Check: Turn switch S1 to 0 ohms, position 2. Voltage across load resistor, 350 ohms, should not exceed 17.0 VDC.

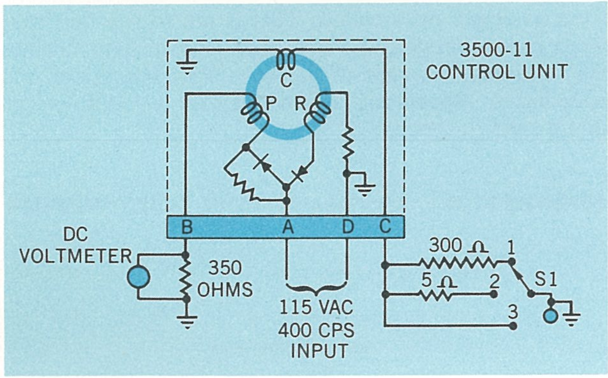


Figure 6. Portable Tester.

The tester illustrated can be fabricated to plug in at the control unit in the aircraft, utilizing the 400-cycle input power from the aircraft supply. This would give a quick check of the control unit function while still in the aircraft. The wire harness to the control unit should be carefully inspected for abrasion and chafing, to preclude short circuits and grounds in this area. A similar tester can be made for the dual loop controller with a few simple changes.

Tests of Fire & Overheat Detector Units. The next major check should be of the continuous detector units. Since the eutectic salt functions as a semi-conductor, caution must be used to avoid damaging the salt by the application of incorrect test voltages.

Continuity Test. Make continuity test as follows:

1. Disconnect each end of firewarning or overheat loop to be checked. Total resistance of the core or center wire from one end of the entire loop to the opposite end shall not exceed 15 ohms. Individual detector element core wires should not exceed 0.2 ohms per foot.
2. Measure the resistance of the detector outer sheath to aircraft structure with accurate low-reading ohmmeter or electrical bridge. Resistance should not exceed 0.01 ohm.

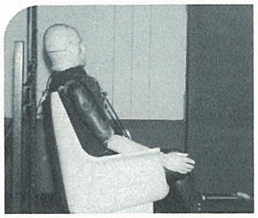
Resistance Test. For this test, a 500-VDC megger may be used for not longer than 5 minutes per hour, provided that no part of the loop is above 150°F (65.6°C). Loops that trigger at 255°F, 265°F, and 310°F (123.8°C, 129.4°C, 154.4°C) should not be tested when the loop is above room temperature. A high resistance ohmmeter, such as a Simpson 260 multimeter, can be used without restrictions at room temperature. When ambient temperature is within 100° of the alarm point of the element, the use of the ohmmeter is restricted to a 5-second application twice a minute, or equivalent use period. Failure to observe these restrictions may damage the eutectic salt, requiring replacement of the detector.

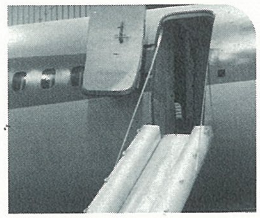
With detector loop disconnected from the test relay and control unit, measure the resistance of the detector center core wire to outer sheath with a 500-volt DC megger or high-resistance ohmmeter. Resistance of the entire loop from core wire to outer sheath should be not less than 100,000 ohms.

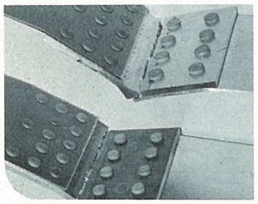
Test and Inspection of Harnesses. Frequently the offending item found, when troubleshooting a false alarm, is simply a wire shorting to the airframe, caused by chafing. Wiring should be carefully checked where it enters or leaves a component, or where bends are made, such as at a cowling door. When testing or replacing a component such as a relay, controller, or detector, inspect the associated wiring while the area is exposed.

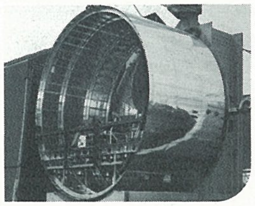
Evaluation of flight crew writeups will assist maintenance crews in troubleshooting the fire warning and overheat systems. It is important that flight crews differentiate between a steady or flashing light when entering fire warning or overheat problems in the log, so as to assist maintenance crews in troubleshooting the proper system. The fire warning system is a "no-go" item—if the system doesn't function, the airplane doesn't go. Care and alertness can keep the fire warning system a "go" item.

DESIGNING FOR CRASHWORTHINESS









A STUDY AND DESIGN CONTRACT has been awarded to General Dynamics / Convair by the Federal Aviation Agency to find and develop design principles and techniques that will increase passenger and crew survivability in such airplane accidents as aborted takeoffs, short landings, over-shoots, wheels-up landings, and ditchings.

The proposed study is divided into four major task areas.

Phase I. Modes and Mechanisms of Failure—This phase will determine which materials and methods of construction are best suited to maintaining fuselage cabin integrity during crash impact loading. Objectives are to restrain and protect the occupants until all motion ceases, as during a crash landing at moderate velocity on relatively level terrain when most of the restraining force results from the bottom of the fuselage sliding over the ground. This type accident generally results in relatively little structural failure, but the mode of failure of the fuselage is patently the area of greatest concern, since the fuselage will be deflected by irregularities in the terrain. It is essential that the structure withstand these deflecting loads without affecting the cabin structure, and that fuselage arrangement be designed to take maximum advantage of the ability of structural members to continue carrying loads long after reaching maximum strength. So that behavior of various structures can be determined, accident investigation reports will be reviewed in the hope of finding a structural material that evidences ductile rather than brittle or shattering failure.

Phase II. Energy-Absorbing Structures—This phase is closely related to Phase I, except that Phase II will emphasize the structural features that affect inertia loads transmitted to the passengers. During this phase, crash investigation and test data that may indicate the effectiveness of such special devices as seat belt energy absorbers will receive special attention, as will the crash-resistant passenger seat.

Phase III. Delethalization Design Principles Study—Objective of this phase is to establish delethalization design principles that will include environmental provisions which will keep the occupant alive, conscious and mobile during a survivable crash. Aspects of delethalization include the presence of objects in the cabin that may become missiles during a crash; equipment and seat restraint or tie-down; energy-absorbing padding; interior trim material; stowage of carry-on cargo and luggage; cockpit equipment and hardware; and the presence of hard, unyielding objects and surfaces.

Phase IV. Evacuation Design Principles Study—This phase will evaluate evacuation principles, considering all factors affecting an occupant's access to a usable exit under emergency conditions. In addition, all available reports, analyses, investigations, and accident briefs will be reviewed to gain information on equipment and seat tie-down failures; galley retention device failures; degree of fuselage collapse; presence of smoke, fumes, fire, and water; electrical shock; available emergency equipment used for evacuation; cockpit and cabin arrangements; exit blockage due to structural collapse; ground rescue attempted; compliance with regulations and directives by the operator and manufacturer.

Convair's experience as a transport manufacturer with an outstanding safety record will provide significant advantage in that Convair will be in a position to use this experience in deriving optimum recommendations from available information. This is not to say that past work can necessarily be reapplied, but, it does indicate that Convair is aware of the economic, operation, and installation aspects of delethalization, as well as the direct safety aspects.

GENERAL DYNAMICS | CONVAIR

VOLUME XV NUMBER 6 MARCH|APRIL 1964

Convair Traveler

In This Issue: Flight Compartment Windshields and Windows

VOLUME XV NUMBER 6 MARCH APRIL 1964

Convair Traveler

In This Issue: Flight Compartment Windshields and Windows

The windshield, or wrap-around cockpit enclosure, of today's high-speed, high-altitude aircraft with its pressurized cabin, has become a sophisticated structural device. It is designed to withstand pressurization loads up to 10 psi, and to resist the impact of hailstones and bird strikes; it is capable of anti-icing, anti-fogging, and/or rainclearing to provide unimpaired visibility for the pilot under all climatic conditions. How Convair's design complied with these requirements, yet provided maximum service life with negligible damage limits and fail-safe qualities, is described herein. Artist: Tommy Thompson.

Convair Traveler

MANAGER, CUSTOMER SERVICE – **O. W. HARPER**
CHIEF ENGINEERING SERVICE – **L. J. BORDELON**
CHIEF, FIELD SERVICE – **R. E. SOMMERS**
CHIEF, SERVICE PARTS – **J. DOIG**
CHIEF, TECHNICAL PUBLICATIONS –
H. R. KENNEDY
EDITOR – **GERTRUDE S. HUNTER**

IN THIS ISSUE

PAGE 3
FLIGHT COMPARTMENT WINDSHIELDS AND WINDOWS
Hugh R. Smith

PAGE 10
CARGO COMPARTMENTS
Limitations & Maintenance
G. S. Hunter

A digest of operation and service published monthly by the Technical Publications Section of GD|Convair, primarily for the interest of Convair operators. Permission to reprint any information from this periodical must be obtained from the Chief of Technical Publications, General Dynamics|Convair, San Diego 12, Calif. Information is to be considered accurate and authoritative as far as Convair approval is concerned. FAA approval is not to be implied unless specifically noted. Recipients of this information are cautioned not to use it for incorporation on aircraft without the specific approval of their cognizant organization.

COPYRIGHT 1964

GENERAL DYNAMICS | CONVAIR

Convair 880/990
Flight Compartment Windshields and Windows

CONVAIR JET AIRLINER COCKPIT WINDSHIELDS were designed to withstand up to 10 psi airplane pressurization; flight loads at speeds up to 400 KIAS; high-altitude cold; and impact forces more than quadruple those of piston-engine transports.

The difficulty in designing windshields to such requirements is that they must be made of glass. Nothing else has been found as practical. Glass is optically efficient, chemically stable, does not weather, and is hard enough to resist scratching. But it is brittle and, by comparison with other aircraft structural materials, not very strong.

A glass pane, to withstand flight and pressurization loads, must be thick. If it is to be fully fail-safe, to the extent that the pilot can dispense with the need for emergency descent if one pane fails, the only possible backup load-bearing element is another glass pane of equal strength.

These considerations dictated the design of the windshields in Convair commercial jet transports. The basic concept of the windshields was worked out in the first detail designs for a jet transport, several years before an 880 was built. The 880/990 windshields are distinctive, possibly unique, among contemporary transports. They are single-panel, five-ply construction, with three glass plies separated by polyvinyl butyral to which plasticizer has been added. The outboard ply on center and main windshields is electrically heated for anti-icing. All windows are heated for anti-fogging; on the center and main windshields, the inboard surface of the middle glass ply is heated, while the sliding and aft side windows are anti-fogged by the outboard side of the inboard glass ply.

Nearly all postwar transports have cockpit windows with vinyl plastic sandwiched between glass plies, and with provision for windshield heating. The distinctive features of the Convair 880/990 windshields are these: 1) They have double safety factors. In the single panel, two plies are load-bearing, and either is capable of bearing all normal flight and pressurization loads with full safety factors. Also, if all glass plies fail, the vinyl alone will retain pressure. 2) The electrical heating is automatically regulated and continuously applied, not by on-off switching but by regulation of voltage.

Design and installation are such that the middle ply normally bears the major pressurization load, with the inboard ply for backup. Middle plies on all except the aft windows are 5/16 inch thick; so also are inboard plies in pilot's main windshields and the sliding windows. Inboard plies of the center windshield and both inboard and middle plies of aft windows are 1/4 inch thick. Outboard plies are protective rather than load-bearing; they are thinner and, in the forward windshields, are heated for anti-icing.

At normal temperatures, the vinyl interlayers add materially to windshield strength. Some years ago, however, FAA tests established that maximum protection against a birdstrike required windshield heat. It softens the vinyl, detracting slightly from basic strength, but providing what glass lacks—enough plasticity to resist impact failure. The 880/990 inboard vinyl layer is kept at 90° to 100° F by windshield anti-fog heat.

The FAA requires that a windshield be able to sustain impact by a four-pound bird at design cruise speed. Though service experience indicates that piston-engine aircraft windshields rarely break from ordinary birdstrikes, Convair recommended keeping Convair-Liner vinyl temperature at 80° minimum. Impact force, however, varies with the square of true airspeed. At *jet* aircraft climb and approach speeds, the impact would be two or three times as great as on Convair-Liners; at anywhere near maximum cruise, bird impact will break almost any glass ply thin enough to be used as an airplane windshield. The vinyl interlayers in the 880/990 windshields are resilient enough to absorb such an impact, and strong enough to contain maximum cabin pressure even if all glass plies should be fractured.

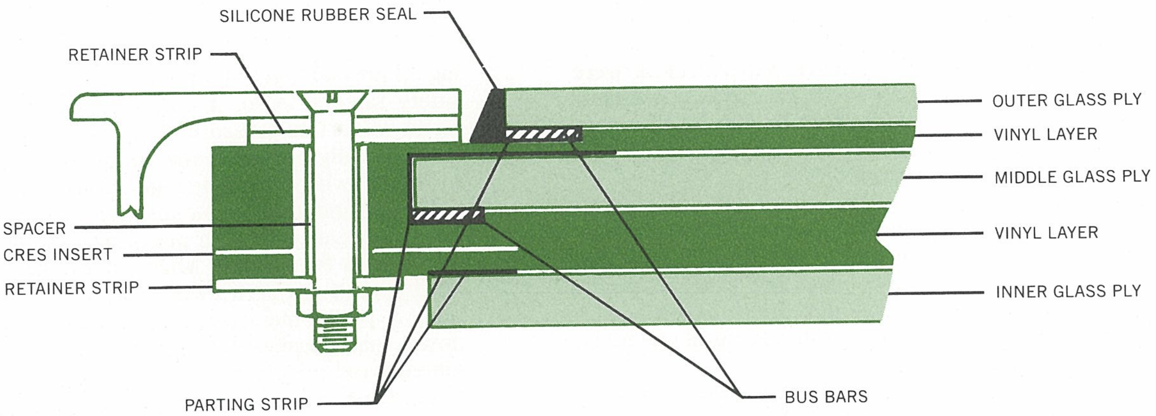
Windshield Manufacture and Inspection

All glass in the windshields is tempered. "Tempering" in this usage has a meaning different from the usual metallurgical sense. It is a toughening process rather than a "drawing" or annealing. The pane is heated to just below the plasticizing point, and surface-cooled rapidly by airblast. The surface sets before the inner core; when cooled, the core is in tension and the surface in compression.

This leaves a residual stress throughout the pane. One effect is a considerable increase in strength under impact or bending load. Another is a heightened resistance to structural damage from scratches; the surface compression tends to prevent the scratch from growing into a crack. A third characteristic is a peculiarity of failure pattern. When the glass does fail from severe impact or strain, it often crazes or cracks over a considerable area, usually over the entire pane.

Degree of temper is indicated by a mu (μ) rating; 2800 μ is full temper. One load-bearing ply in each windshield is fully tempered. It is not, however, possible to fully temper a panel less than 1/4 inch thick, nor a panel coated with electrically conductive heating material. The coating must be sprayed on, with the glass at a high temperature, in which process some temper is lost. The thin outboard ply in each windshield, therefore, and the heated plies are at less than full temper. A chart of the μ ratings and the thickness of the glass and vinyl plies in each windshield is printed herewith.

It is evident that the manufacture of such a windshield demands highly developed techniques and painstaking care. Each pane must be cut to size before tempering. The furnace tong marks can often be seen, 1/4 to 1/2 inch from the edge; they appear as small opposed dimples and are sometimes mistaken for flaws.



Windshield Construction (Typical)

PLY THICKNESSES AND MU RATINGS

	Outboard Glass Ply			Outbd. Vinyl	Middle Glass Ply			Inbd Vinyl	Inboard Glass Ply		
Window/ Windshield	**MU Rating**	**Thick-ness**	**Heating Coat**	**Thick-ness**	**MU Rating**	**Thick-ness**	**Heating Coat**	**Thick-ness**	**MU Rating**	**Thick-ness**	**Heating Coat**
Center Windshield	1800	3/16	Anti-ice on inbd. surface	.180	2000	5/16	Anti-fog on inbd. surface	.300	2800	1/4	None
Pilot's and Co-Pilot's Main W/S	1800	3/16	Anti-ice on inbd. surface	.080	2000	5/16	Anti-fog on inbd. surface	.300	2800	5/16	None
Sliding Window	1800	3/16	None	.240	2800	5/16	None	.240	1800	5/16	Anti-fog on outbd. surface
Aft Window	1200	1/8	None	.160	2800	1/4	None	.180	1800	1/4	Anti-fog on outbd. surface

Wheatstone Bridge resistance measurement of windshield sensors is part of Receiving Inspection.

When the panes are tempered and the required heating coats applied, the windshield is assembled. The vinyl, in sheets .020 to .040 inch thick, is laid over the panes. Sensor control grids and bus bars are located, and the leads run out to a terminal strip. A quarter-inch parting strip is applied along the pane edges, between glass and vinyl. Metal retainer strips frame the windshield, predrilled for mounting screws. Metal spacers prevent deformation of the vinyl during mounting. Between inboard and middle glass plies, a metal reinforcing strip is inserted.

The assembly is taped together, enclosed in a polyethylene bag, and air is exhausted from the bag. The vinyl is fused and bonded to the glass by heating under pressure in an oil-bath autoclave. Finally, neoprene sealing strips are bonded to the edges to prevent moisture penetration into the interlayers.

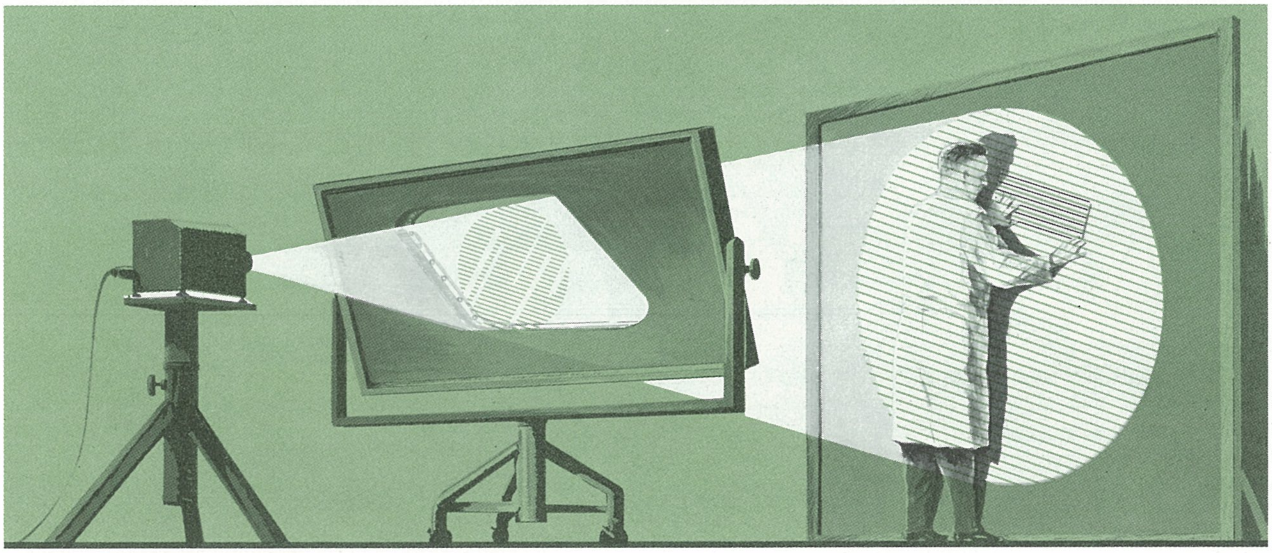
Although the manufacturer routinely tests and inspects all units, Convair Receiving Inspection thoroughly checks and rechecks each unit functionally, optically, and dimensionally. Scratch depth limitations are exceptionally tight (less than .001 inch). Scratch depths are measured with optical micrometers and dial micrometers with needle probes.

A Functional Test Instruction report form accompanies each panel, outlining test requirements and methods. The glass is first checked dimensionally for contour, periphery, routing, and drilling. Dielectric tests determine satisfactory insulation of sensors and bus bars from each other and from ground plane inserts and frames. Sensor resistances are accurately measured. A complete historical record is kept on each panel.

The next check is for optical distortion. A projector containing a rotatable transparent photo-etched grid is positioned relative to the glass so as to simulate the distance of the windshield from the pilot's eye. It projects through the panel a pattern of straight lines onto a seven-foot-square frosted glass screen. Distortion from any irregularity in one of the six surfaces of the glass will show as a fogging or angular displacement of the grid lines. The inspector checks the lines with a transparent template, and measures any angular displacement exactly. Grid lines may be rotated or stopped down by a remote control operated by the inspector, so as to show up distortion in any plane.

Engineering has established distortion limits in various areas of the windshields, depending on their importance, for accurate vision in flying the airplane. It may be noted that Convair specifications regarding distortion are much stricter than equivalent military specifications generally used throughout the industry. Earlier in the program this placed such a burden on the suppliers that they insisted on military specifications as an alternate on the purchasing paper. The cost of windshields of this quality level, meeting military specifications but not up to Convair specifications, was absorbed by Convair and the units were used for destructive testing.

A percentage of all new units, and all of the in-house



In glass transparency test, "glass" camera, simulating pilot's eye, projects grid pattern through transparency being checked. Lines will be bent when distortion is present.

Convair inspector monitors cold chamber test of windshield glass.

or customer-returned challenged items, are given an environmental test in addition to the rigid inspection. They are placed in a cold chamber, and temperature readings taken down to −65° F. By duplicating aircraft power and control boxes, and by substituting decade boxes for the sensors, the actual heating characteristics of each unit can be determined and recorded in detail.

Any flight compartment glass bearing a Convair Receiving Inspection functional test acceptance stamp can be considered fully acceptable functionally, optically, and dimensionally.

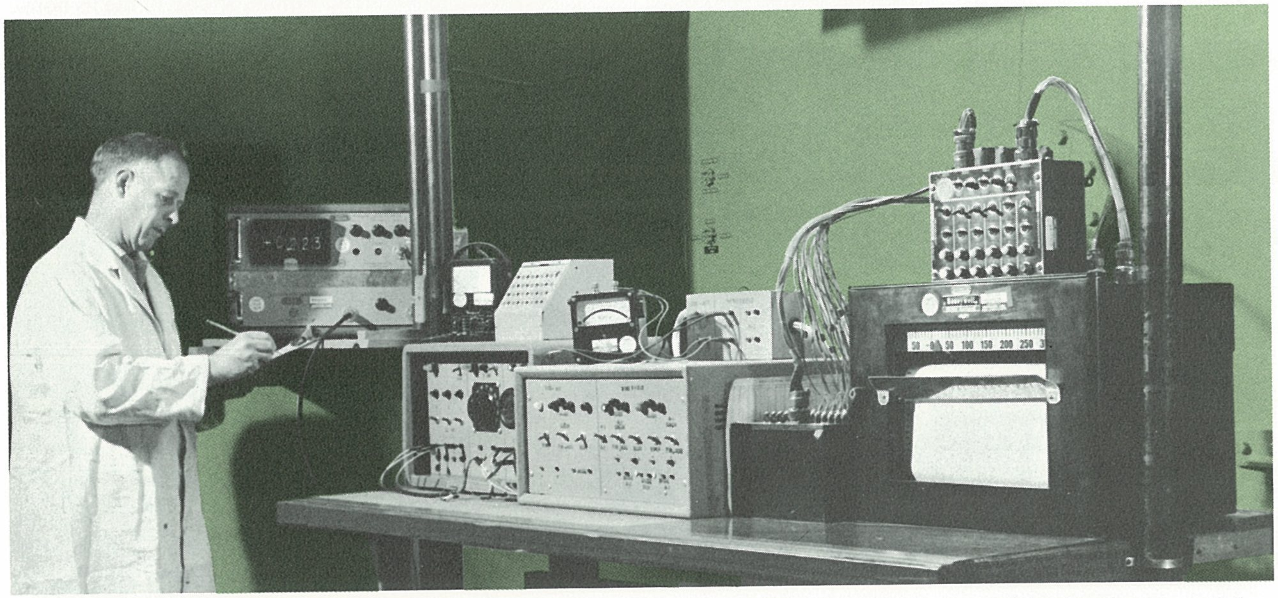
Windshield Heat

In each of the three forward windshields – pilot's and copilot's main and center – there are two heating elements, one for anti-ice and one for anti-fog. They are electrically conductive coatings of stannic (tin) oxide applied to the inner surface of the outside glass ply for anti-ice, and to the inner surface of the middle ply for anti-fog. Up to 2000 watts power can be applied to the anti-ice coating, and 600 watts to the anti-fog. Approximately 1800 BTU/hr/sq ft is supplied to the outside surface of the panel, 600 BTU/hr/sq ft to the inside surface. Anti-fog coatings in sliding and aft windows are on outboard surfaces of the inboard glass plies and supply 240 BTU/hr/sq ft to the inside surface.

There are five control boxes for windshield heat: one each for pilot's, center, and copilot's windshields, one for the two sliding windows, and one for the two aft windows. Five corresponding switches are on the overhead panel in the flight compartment. All switches are normally turned on to provide anti-fog and bird-proofing heat on takeoff.

The Convair 990 switches are three-position – OFF, ANTI-ICE, and ANTI-FOG; 880 switches are two-position. The three forward windshield switches in the 880 are labeled ANTI-ICE in the "on" position, sliding and aft switches are marked ANTI-FOG. In the "on" position, however, unless anti-icing is specifically demanded, the switches turn on anti-fog only.

Originally, 880 anti-ice and anti-fog systems were tied in with ice detectors in the engine inlets. Then, with the main anti-ice switch (on another overhead panel) in AUTO position, an encounter with icing would automatically switch windshield heat from anti-



Wires to sensors and bus bar inputs in environmental chamber are routed to controllers outside chamber, permitting control from substitute airplane control boxes or from artificial signal from a decade box.

*FAILURES OCCURRING IN FLIGHT

CONDITION	WINDSHIELD	ACTION REQUIRED	RESTRICTIONS DURING FLIGHT
Anti-ice inoperative, anti-fog operative	Main and center	Use rainclearing to anti-ice main windshields if necessary.	990: No restrictions. 880: During flight in icing conditions requiring main anti-ice switch to be on, restrict speed under 10,000 ft. to 300 knots CAS.
Anti-fog inoperative, anti-ice operative	Main and center	Use anti-ice to defog as required.	Restrict speed below 10,000 ft to 300 knots CAS. Limit anti-ice heat to 15 minutes (880) or 30 minutes (990) at a time; then turn off until windshield starts to fog, and repeat cycle as necessary.
	Sliding and aft	None.	No restrictions.
Anti-fog and anti-ice both inoperative	Main and center	Use rainclearing to anti-ice main windshields if necessary.	Restrict speed below 10,000 ft to 300 knots CAS.
	Sliding and aft	None.	No restrictions.
Arcing	Main and center	Turn off all power to affected windshield. Use rainclearing to anti-ice main windshields if necessary	Restrict speed below 10,000 ft to 300 knots CAS.
	Sliding and aft	Turn off all power to affected window.	No restrictions.
Breakage – any one ply	Main and center	Turn off all power to affected windshield.	Restrict speed below 10,000 ft to 300 knots CAS. No pressurization limitations.
	Sliding and aft	Turn off all power to affected windshield.	No restrictions.
Breakage – outer and one other glass ply (no bulging evident)	Main and center	Turn off all power to affected windshield. Descend at normal rate until cabin pressure differential does not exceed 6 psi.	Restrict speed below 10,000 ft to 300 knots CAS; 6 psi maximum pressure differential.
	Sliding and aft		No speed limitation; 6 psi maximum pressure differential.
Breakage – two inner plies or all plies; bulging (½ inch or more) may be evident.	Main and center	Turn off all power to affected windshield. Descend at normal rate until cabin pressure differential does not exceed 5 psi.	Restrict speed below 10,000 ft to 300 knots CAS; 5 psi maximum pressure differential.
	Sliding and aft		No speed restriction; 5 psi maximum pressure differential.

*Authority: FAA Flight Manual

NOTE: 300 knots CAS is equivalent to 298 knots IAS (880) or 301 knots IAS (990). Difference is due to pitot position error.

Table 1.

fog to anti-ice. This circuit has, however, been deactivated on most aircraft in favor of manual switching (Service Bulletins 880 30-18A, 880M 30-2A). The windshield circuit is then controlled by the main anti-ice switch ON position (AUTO position being inoperative); that is, when the main anti-ice switch is turned ON, windshield heat is switched to anti-ice.

In all aircraft, when the airblast rainclearing is turned on, both anti-ice and anti-fog circuits in the pilot's and copilot's main windshields are deactivated by deenergizing the control relays.

Windshield heat control boxes have saturable core transformers with magnetic amplifiers, governed by sensors that vary the voltage applied to the heat coatings. The sensors are resistors in the windshield panels, and can be seen as grids of fine wire embedded in the vinyl, one for each coating in the windshield. Sensors operate on 28-volt dc; current through the heaters is ac, usually at 100 to 200 volts potential.

Damage Limitations and Flight Requirements

Intent of Convair engineering was to design a windshield with maximum service life, high negligible damage limits, and fail-safe qualities that would eliminate the need for emergency descent because of a failure.

Service experience, and thorough evaluation of the results of the test program, indicated that the goal was achieved. As a result, Convair-recommended damage limits specified in the Maintenance Manual, and in-flight pressurization limits in event of failure, are unusually liberal.

MINIMUM REQUIREMENTS FOR ALL FLIGHT

CONDITION	WINDSHIELD	*REQUIREMENTS
Anti-ice	Pilot's and Copilot's Main Windshield Panels	Not required for flight into non-icing conditions. Either pilot's or copilot's (not both) may be inoperative for flight into icing conditions, provided rainclearing is operative.
	Windshield Center Panel	May be inoperative for all flight conditions except as required when anti-fog is inoperative.
Anti-fog	Pilot's and Copilot's Main Windshield Panels	Either copilot's or pilot's (not both) may be inoperative provided that AFM speed and altitude restrictions are observed, and provided that anti-icing is operative on the panel with anti-fog inoperative. (Anti-icing requirement insures anti-fog capability.)
	Center Windshield Panel	May be inoperative provided that AFM speed and altitude restrictions are observed and that anti-icing is operative on center windshield. (Anti-icing requirement insures anti-fog capability.)
	Sliding and Aft Windows	No requirement.
Anti-ice and anti-fog both inoperative	Pilot's and Copilot's Main	Dispatch not permitted.
	Center	Dispatch not permitted.
	Sliding & Aft Windows	No requirement.
Rainclearing	Windshield	Required for operation in precipitation within departure and arrival areas and as required when pilot's or copilot's windshield anti-ice is inoperative. When permitted inoperative, valve must be fixed in the closed position.

*Ref: Revised FAA Minimum Equipment List

Table 2.

Results of a few of the many structural tests on the windshields will illustrate the basis for Convair's recommendations.

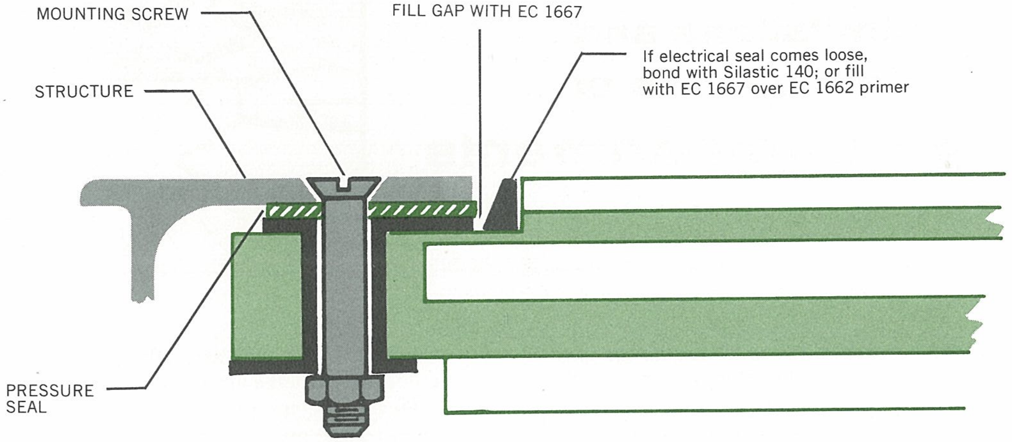
In birdproofing qualification, where a total of 29 four-pound chickens were shot by a special gun at the windshield and its supporting structure, it was established that with normal heating, the windshield would withstand the impact at VNO (375 knots CAS): and without heating at 300 kts CAS. A 300-knot limitation below 10,000 ft with anti-fog inoperative remains in the Flight Manual. Above 10,000 ft, where birds are rarely found, there is no speed limitation.

In static tests of a sliding window with all panes completely fractured, the vinyl sustained 21.5 psi loads twice, and, on a third test destruction, failed at 64 psi. In a simulated failure at 35,000 ft with 8.3 psi pressurization, a main windshield was broken by repeatedly dropping a 25-pound weight on it from a 12-foot height until all panes were fractured. The panel was cooled to 10° F and left under pressure. After 10 hours, the vinyl showed a bulge of only 1 inch. Temperature was raised to 82° F, and the panel was pressurized 16 hours more. By this time, the vinyl showed a maximum deflection of 5-3/4 inches. Then, after 26 hours under maximum aircraft pressurization, pressure was gradually increased to 17.5 psi before the vinyl failed.

ALLOWABLE GLASS BREAKAGE FOR SPECIAL DISPATCH
(See text for application)

CONDITION	WINDSHIELD	FLIGHT RESTRICTIONS	AUTHORITY
Breakage—any ply	Pilot's and copilot's main	Dispatch not permitted (anti-fog and anti-ice both inoperative).	Minimum Equipment Lists
Breakage—outer ply only	Center	Observe in-flight speed restriction with anti-fog inoperative.	FAA Flight Manual
		No pressurization restrictions.	Convair recommendation
	Sliding and aft	No restrictions.	Convair recommendation
Breakage—middle or inboard ply, but not both	Center	Observe in-flight speed restriction with anti-fog inoperative.	FAA Flight Manual
		Limit cabin pressure differential to 6 psi.	Convair recommendation
	Sliding and aft	No speed limitation. Limit cabin pressure differential to 6 psi.	Convair recommendation
Breakage—outer and one other ply	Center	Observe in-flight speed restriction with anti-fog inoperative.	FAA Flight Manual
		Limit cabin pressure differential to 5 psi.	Convair recommendation
	Sliding and aft	Limit cabin pressure differential to 5 psi. No speed limitation.	Convair recommendation
Breakage—two inner plies, or all plies	Any windshield or window	Dispatch not recommended.	Convair recommendation

Table 3.


MOUNTING SCREW
FILL GAP WITH EC 1667
If electrical seal comes loose, bond with Silastic 140; or fill with EC 1667 over EC 1662 primer
STRUCTURE
PRESSURE SEAL

Windshield Installation (Typical)

Results from these and other tests in the program, and experience in service, enabled Convair not only to liberalize Maintenance Manual restrictions, but to make definite recommendations on pressurization for flight under various conditions of windshield damage. They are included in the tables on pages 7 and 8.

These tables represent an effort to assemble in one place, in as simple a form as possible, several sets of regulations and recommendations on takeoff and flight requirements and limitations applicable at this time. Three sources are involved: the FAA-approved Flight Manuals (essentially identical in this respect for all 880 and 990 aircraft), the FAA Minimum Equipment Lists, and the manufacturer's recommendations. These sources should not conflict; they sometimes overlap, and one set of parameters affects another. The ensuing complexities have given rise to questions from pilots and operators. The information is subject to change, and the sources should be checked for up-to-date operational information.

Table 1 presents Flight Manual restrictions and Convair's recommendations for in-flight failure situations. Table 2 presents the basic MEL (Minimum Equipment List) requirements and their effect on flight procedures.

Table 3, "Allowable Glass Breakage for Special Dispatch," came about in response to requests from operators for information on the circumstances under which an airplane with windshield damage could safely take off and continue on its route, on a revenue passenger flight, to a base where windshield replacements would be available.

This situation is particularly vital on some overseas routes where grounding an airplane at an out-of-the-way airport may cause extensive delay before parts can be flown in. Table 3 gives what Convair considers minimum requirements for such a flight, *based on structural considerations alone,* and subject to the formal limitations of the Flight Manual and the MEL. Visibility considerations are omitted from Table 3.

It may be noted that the flight speed restriction applies any time anti-fog heat is inoperative for birdproofing the three forward windshields. It applies, therefore, whenever power must be cut off to the windshield, as, for example, whenever there is arcing or breakage of any ply. Under MEL terms, dispatch is not permitted with neither anti-ice nor anti-fog heat available for the pilot's and copilot's main windshields. Any breakage in these panels, therefore, would prohibit dispatch, even though structurally they would be satisfactory.

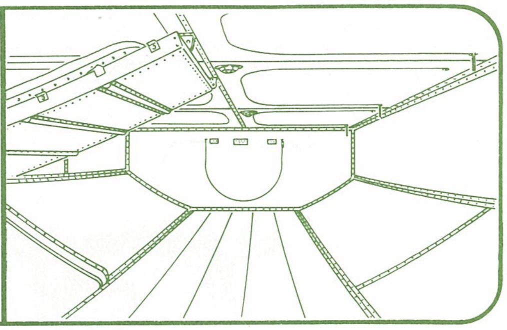
It will be understood that all these tables deal with minimal requirements. Operators may have other considerations that would dictate additional restrictions.

Maintenance

Windshield and window panels should be handled carefully during removal. Many are repairable, but they can be easily damaged beyond repair by careless handling. In addition to the procedures in Chapter 56 of the Maintenance Manual, following are some precautions to observe:

1. Apply protective paper to both surfaces before removal.
2. Since pressure seals can be reinstalled if not damaged, be careful of them during removal. Do not use tools to pry panel out of support structure. If it is difficult to break the seal between panel and frame, bump windshield inward with heel of hand.
3. In replacing pilot's windshield, the rainclear overheat sensor must be removed. This sensor is bonded to a titanium retainer plate. Since it cannot be rebonded in the field, the bond should not be broken. Disconnect the cannon plug on the sensor lead and slide the retainer plate from the grooves in the rainclear nozzle.
4. Provide support for window glass during transportation and shipping.

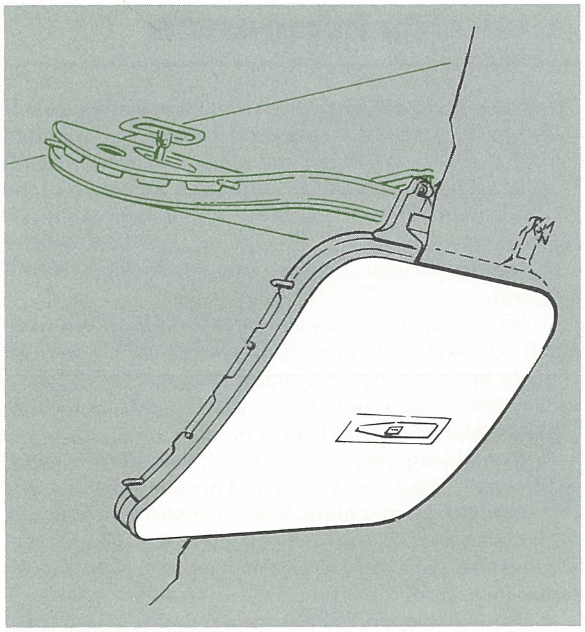
Limitations and Maintenance of Cargo Compartments



CARGO AREAS IN CONVAIR JET AIRLINERS are designed to comply with Civil Air Regulation 4b.382 for Class "D" cargo and baggage compartments. A Class "D" compartment is designed and constructed so that 1) a fire occurring therein will be completely confined without endangering the safety of the airplane or its occupants; 2) infiltration of air to the cargo compartment is insufficient to support a fire.

In Convair jet airliners, pressure between the main cabin and the cargo compartments is equalized by a 2-3/4-inch hole over the door of each compartment. Except for these small pressure equalizing openings, the compartments are airtight and hence provide only limited oxygen for supporting live cargo. The compartments receive a limited amount of heating from cabin air which is discharged into the space between the fuselage skin and the compartment lining, before being ducted overboard. Blowout panels are provided for rapid decompression.

Two luggage/cargo compartments are provided, one forward and one aft of the wing. Access to the compartments is by plug-type doors that open inward. On some Convair 990 aircraft, there are two doors for access to the aft cargo compartment.



Hinge type door, open and closed positions.

Hinged doors provide access to the Convair 880 forward and aft cargo compartments, and to the 880M aft cargo compartment. Sliding doors are used in the forward cargo compartment of the 880M and in the forward and aft compartments of the 990.

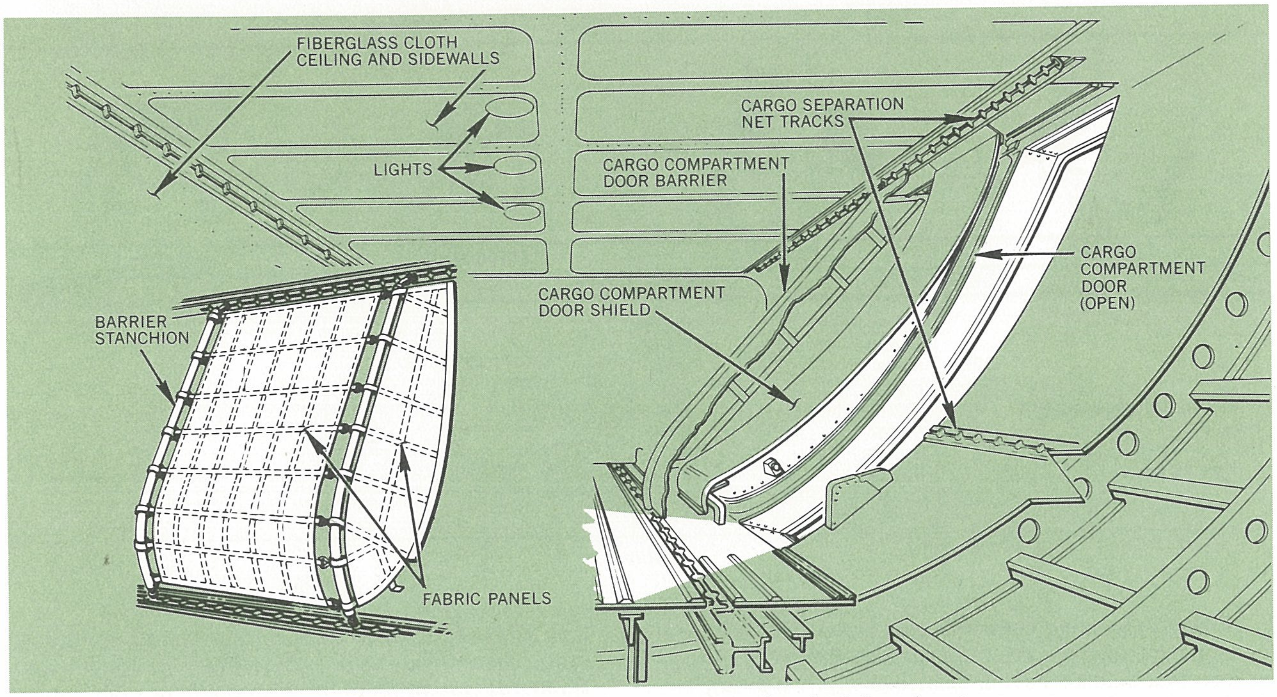
The 880 type doors are hinged at the top. When open, a spring-loaded hook in the door engages a pin in the top of the cargo compartment to hold the door in the UP position. The door control handle may then be pushed back into its recess without releasing the door hold-open mechanism. To unhook the door, the control handle is rotated outward from its recess to release the hook, thus allowing the door to be closed.

A snubber mechanism controls the rate at which the doors are opened and closed so as to prevent damage to the door, hinges, and door mechanism, and to prevent injury to personnel. The doors should be operated only at a smooth, moderate rate. Any attempt to speed up the door opening rate only adds to the loading which may already be acting through the door snubber. Snubber bolt breakage can result.

To ensure clearance for door opening, a barrier is installed around the door opening. In the aft compartment, the forward and aft sides of the barrier are formed by straps while the inboard side is a fiberglass panel reinforced with three aluminum hat sections. The inboard panel is hinged at the top and is held in place at the bottom with spring-loaded pins. With the cargo door open and latched, the barrier panel can be swung outboard and hooked to the outboard corners of the cargo door.

The forward compartment on the Convair 880 has nylon web type barriers forward and aft of the door. Each side is secured to the aircraft structure on the outboard side, and to a removable stanchion at the inboard end. The inboard panel, also of nylon webbing, is attached to the two stanchions that support the side barrier. With the cargo door open, entrance to the compartment is gained by releasing six clips that secure the inboard side of the barrier to the aft stanchion, and folding the inboard barrier out of the way.

On the Convair 990 (and in the forward compartment of the 880M), the plug-type doors move inward, then forward on tracks, permitting maximum utilization of space in the compartment. The doors are opened by depressing a catch in the center of the door


FIBERGLASS CLOTH CEILING AND SIDEWALLS
LIGHTS
CARGO SEPARATION NET TRACKS
CARGO COMPARTMENT DOOR BARRIER
CARGO COMPARTMENT DOOR (OPEN)
BARRIER STANCHION
CARGO COMPARTMENT DOOR SHIELD
FABRIC PANELS

Convair 990 cargo compartment showing detail of door barrier.

control handle, allowing the door handle to swing out of its recess. The handle can then be rotated 90 degrees to unlatch the door. Pushing the door inboard engages the door with tracks in the fuselage. The door handle is then returned to the latched position, and the door is free to slide forward on the tracks to clear the door opening.

A barrier is installed at each sliding door to prevent baggage resting against the door. These barriers, of web-type construction, are attached to stanchions at the inboard end and to channels at the outboard sides. Spring-loaded pins on the stanchions permit easy removal and installation of the barrier.

Although the forward and aft cargo doors on all configurations open inward, they are normally protected to prevent door blocking by contained cargo and luggage. Operators, however, have reported instances in which luggage placed aboard at the last minute shifted during flight and inadvertently blocked the cargo door sufficiently that it could not be opened from the outside.

No luggage should be placed outboard of the web gate, and the gates should always be firmly attached. Where bins are used, luggage should be firmly packed in the bin—not thrown on "top of the heap" where it can fall off and block the doorway.

In the event the door is blocked, the following steps can be taken to gain access to the compartment from inside the airplane to clear the door on 880 and 880M aircraft.

- Remove the center cabin floor carpet over the affected cargo compartment.
- Remove center floor panel adjacent to the blocked cargo door.
- Cut cargo compartment ceiling liner as required to gain access to the compartment.
- The liner should be repaired before the next flight, at least with a temporary repair, so as to maintain cargo compartment Class "D" requirements.

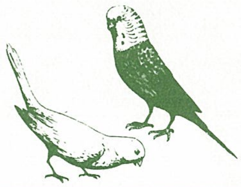
On Convair 990 aircraft, access is gained by removing the carpeting and outboard floor panel, which extends under the seats and immediately above the door area. The floor panel may be moved forward or aft without removing the seats. Removal of the center floor panel is not recommended since most of the area beneath the center aisle and above the forward compartment contains a considerable number of electric wiring harnesses.

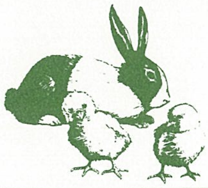
Shipment of Live Cargo

Convair's Class "D" compartments have an air flow of 600 cubic feet per hour or 10 cubic feet per minute. Minimum comfort air flow required for one passenger is 7-1/2 to 10 cubic feet per minute. Thus, it can be seen that cargo compartments do not contain sufficient oxygen to support more than one man or an equivalent number of animals, depending on type and size of animals, outside air temperature, and length of flight.

Convair flight test data for 880 aircraft show forward cargo compartment floor temperatures varying from 41°F to 50°F when either loitering or cruising at 25,000 feet altitude with an outside air temperature of −4°F. Aft cargo compartment temperatures tend to be a few degrees lower. These temperatures decrease with increase in altitude.

CATEGORIES AND WEIGHTS OF ANIMALS





CATEGORY A		CATEGORY B		CATEGORY C		CATEGORY D	
TYPE	WEIGHT	TYPE	WEIGHT	TYPE	WEIGHT	TYPE	WEIGHT
Finch Canary Pheasant Chicks (1 day old) Parakeet Other Small Birds less than .18 lbs. ea.	.0256 .0359 .0408 .0606	Mice (white) Chicks (1 day old) Myna Pigeon Rats (white) Parrot Guinea Pigs Rabbits Other Large Birds .18 - 5.0 lbs. ea.	.0523 .0589 .184 .662 .666 .811 1.58 5.7	Dogs less than 25 lbs. ea. Mink-Female Mink-Male Chihuahua Fox (Gray) Fox (silver-Female) Fox (silver-Male)	- 1.75 2.25 6.15 8.38 11.0 13.5	Dogs over 25 lbs. ea.	

Table 1.

Courtesy—Delta Air Lines

Although the cargo compartments are not designed for shipment of live cargo, from these figures it can be seen that animals have a chance of survival if they are limited in size or quantity or are airborne for short periods of time only, at flights below 25,000 feet altitude, and if proper loading procedures are observed. A small animal accustomed to low temperatures could survive an extended flight.

Some Convair jet airliner operators regularly transport live cargo with a high measure of success. One Convair 880M operator has successfully shipped mice, lizards, monkeys, and snakes from South America to New York for distribution to zoos. A domestic Convair 880 operator, who has many requests for transporting live cargo, successfully ships small animals and birds cross-country. Shipments of inoffensive animals, such as rats and mice for laboratory use, are shipped in accordance with applicable state regulations. The following procedures and standards established by this operator, plus some precautions, are suggested to protect the animals during shipment.

- Shipments of animals and birds are loaded in belly compartments, and care is taken that they are not placed within two feet of heater outlets or within one foot of a heater duct. Shipments are kept within a temperature spread of 64°F to 80°F, and they are protected from the elements and not allowed to become cold or wet.
- Animals are not loaded in belly compartments if both turbocompressors are inoperative, or if the airplane will operate unpressurized for any reason.
- If a flight is delayed, the compartment door is kept open until just before departure. If a delay is antici-

MAX. ALLOWABLE WEIGHT OF ANIMALS FOR PRESELECTED HOURS OF CONFINEMENT
(Based on 100 cu ft of free air volume)

HRS./MIN. OF CONFINEMENT	ALLOWABLE WEIGHT OF ANIMALS (POUNDS)			
	CATEGORY A	CATEGORY B	CATEGORY C	CATEGORY D
1:00	up to 35	up to 155	up to 245	up to 550
1:15	up to 30	up to 130	up to 205	up to 475
1:30	up to 27	up to 120	up to 185	up to 425
1:45	up to 25	up to 110	up to 170	up to 380
2:00	up to 23	up to 100	up to 155	up to 350
2:15		up to 93	up to 145	up to 325
2:30	up to 20	up to 87	up to 135	up to 300
2:45		up to 83	up to 130	up to 285
3:00	up to 18	up to 80	up to 125	up to 275
3:30	up to 17	up to 75	up to 118	up to 250
5:00 and over	up to 15	up to 65	up to 105	up to 220

Note: On flights of less than one hour duration, load to compartment capacity provided that:
1. 100 cubic feet of free air volume remains in compartment after loading animals and their containers.
2. Cargo is not loaded on top or within six inches of any side of containers.

Table 2.

Courtesy—Delta Air Lines

MAXIMUM ALLOWABLE LOADS OF ANIMALS IN CARGO COMPARTMENTS

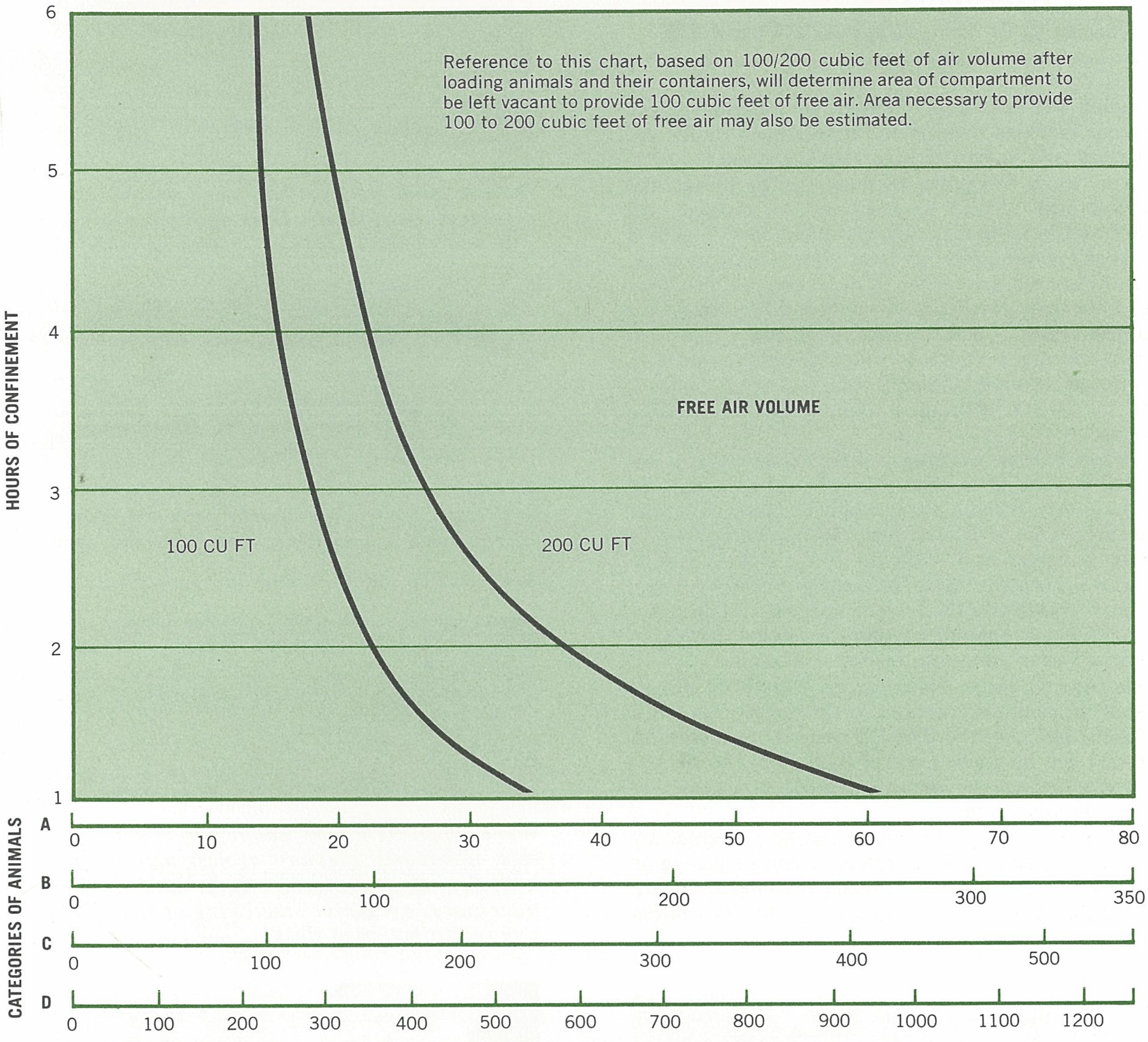


Table 3.

Courtesy—Delta Air Lines

pated, kennels are left on the ground outside the aircraft until just before departure.

- Animals are loaded as close to the door as possible, with the floor of the shipping container in a level position. The shipping container is securely tied down in the event of turbulent weather conditions.
- Live animals are not loaded in the same compartment with a shipment containing dry ice.

The amount of oxygen required for animal shipment varies with the type of animal being carried, and length of the trip or the amount of time during which the compartment will remain closed. A minimum of 100 cubic feet of air space is provided for any live cargo. To determine the number of animals that may be carried: 1) check the average weight and category of the animal in Table I; 2) ascertain the total weight permissible in Table II (for 100 cu ft air space) or the Graph above (for 100 to 200 cu ft air space); and 3) compute the number of animals that can be carried.

For example: Assume that day-old chicks can be boarded on an 880 two-hour flight; how many can be carried with 100 cu ft air space?

According to Table I, day-old chicks weigh .0589 lb and are category B in oxygen requirements.

According to Table II, 100 lb of category B cargo can be carried with 100 cu ft of air space.

By dividing 100 lb by .0589, approximately 1700 chicks can be carried.

The tables can be used conversely to determine air space requirement or maximum length of flight for a specific shipment.

The foregoing procedures as established by Delta Air Lines are considered most thorough; however, decision to transport live cargo is at the operator's discretion.

Maintenance of Cargo Compartments

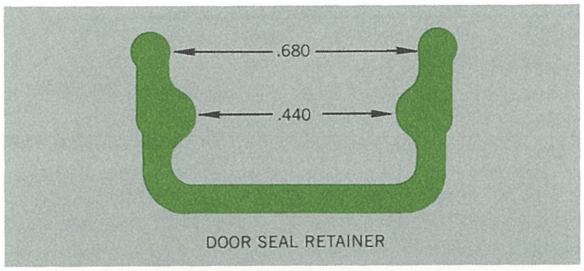
Loading and unloading of cargo requires caution and care to preclude damage to compartment doors and interiors, and to protect passengers' luggage.

After each unloading of heavy cargo pieces, the compartment should be inspected for damage. All tears and punctures in compartment linings should be repaired promptly, at least with a temporary repair, before the next flight. If these compartments are not kept tight, they cannot smother a fire and hence do not meet C.A.R. requirements for Class "D" compartments. Protection of luggage requires smoothing out or repairing all rough areas—door sills, attaching hardware, damaged floors—before loading luggage.

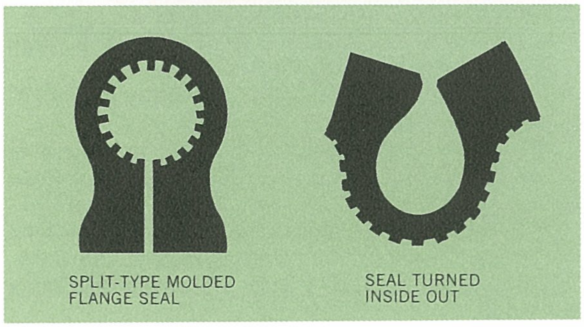
Nylon barrier webbing should be repaired as required to prevent damage to equipment and/or injury to personnel. If the nylon webbing is pulled out of the attaching clips, it can be resealed by searing with a cigarette lighter or a soldering iron. Celulose acetate butyrate, normally used for sealing cotton webbing, is NOT recommended for sealing nylon webbing, because it has a tendency to dissolve nylon, with subsequent loss of strap-to-attachment retention.

Damage to cargo doors can be caused by distortion of the door seal retainer. If the retainer becomes pinched, reducing the 0.680 dimension (see sketch), the seal will be pushed out of the retainer to the extent that it may be abraded by the door jamb or striker during closing.

Seal damage from this cause can be prevented by periodic inspection of the retainer, and reshaping as required. It may not be necessary to remove the entire seal—only in suspected areas—for inspection purposes.

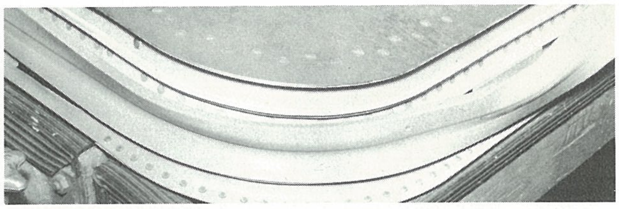


DOOR SEAL RETAINER

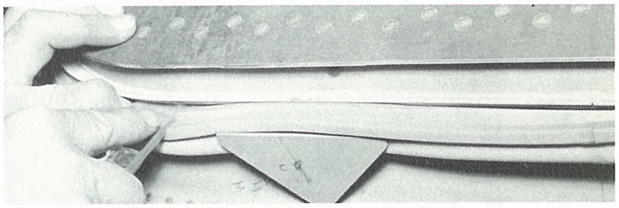


SPLIT-TYPE MOLDED FLANGE SEAL

SEAL TURNED INSIDE OUT

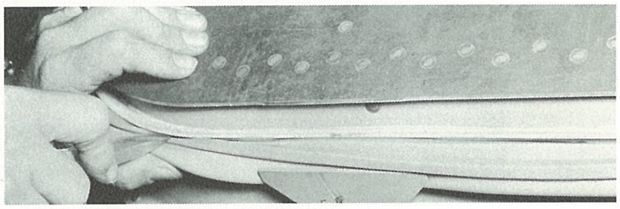


Before positioning seal in door retainer, loop it over (turn it inside out) so that, when placed in position in retainer, the ribbed side is against retainer, and lip with vent holes is on side toward outboard door skin.

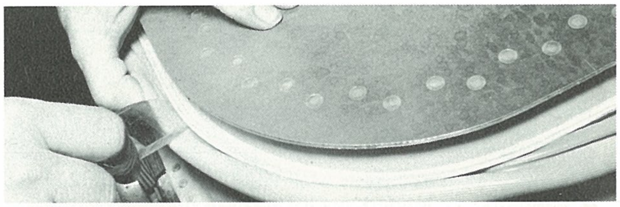


Position seal on retainer, being careful not to stretch seal excessively. Care should be taken also to ensure that the seal is not damaged on any rough metal edges.

Work this lip under retainer for approximately 6 inches.



While supplying downward pressure against top lip with tool, use thumb pressure against bottom lip to bring both lips of seal together under retainer flange. Unnecessary, excessive stretching of seal will necessitate redistribution of slack, a time-consuming operation.



Continue working around periphery of door, engaging both lips of seal in small amounts—approximately one tool width at a time—under retainer flange. Do not slide tool along seal under retainer. Seal damage can result.

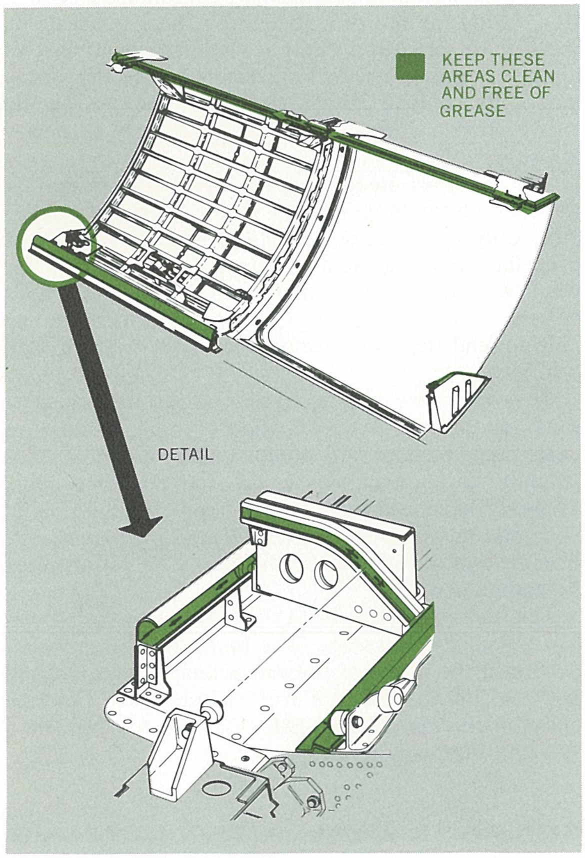
If seal has been stretched, distribute slack to the engaged areas by working seal both ways from slack area.

Operators who have experienced difficulty in installing the molded flange type seals on the hinged cargo doors, may find that the following procedures with photographs will facilitate installation. (This type seal is also used on electrical/electronic and hydraulic compartment doors.)

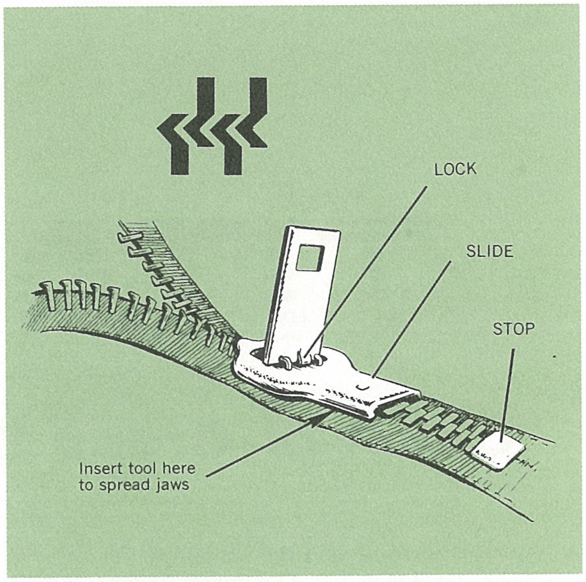
Collection of water inside the cargo compartment doors is possible when aircraft operate in and out of extremely humid climes. This is apparently caused by condensation when warm moist air contacts the cold surface. When checking the outside of these doors upon arrival into a humid area, the outside skin of the cargo door may be covered with condensate similar to that which collects on the lower surface of the wing after flight.

Installation of polyurethane foam on the door interior will prevent interior condensation. This installation is detailed in Convair Jet Airliner Service Newsletter, Vol. IV, No. 13, dated 1 December 1963.

Door tracks in 990 cargo compartments (and in forward 880M compartment) should be kept free of dirt and foreign material that could restrict free movement of the door and barrier. These tracks do not require lubrication. A greased or oiled track could make the door susceptible to binding. Foreign matter—sand, dirt, small bits of paper, etc—adheres to the grease, restricting free operation of the rollers in the track. Only the internal bearing surfaces of the rollers require lubrication.



Tracks for sliding doors are susceptible to binding and must be kept free of grease and foreign matter.



The useful life of zippers in access panels of cargo compartments can be prolonged with proper care. Zippers are an intricate mechanism, and they require careful handling to preclude jamming and otherwise improper operation. Each tooth of the slide fastener has a hook on one side and an indentation on the opposite side. When mating parts are properly engaged, one fits inside the other, forming a locking, or meshing action. To close a zippered compartment, the flap is held in the closed position; then the zipper tab is pulled parallel to the line of the zipper—never at an angle. Panels should be unzipped all the way, and snap fastener straps used to keep panels out of the way, so that they are not walked upon. Zippers should be opened with the slide only.

If a thread or piece of material has been caught in the mechanism, it may be cut out of the jaws of the slide and pulled out. However, if it is necessary to spread the jaws of the slide to remove the thread, the jaws must be clamped back into place. In this event, it is necessary that they be properly aligned, or the slide may again jam or may come off one row of teeth, failing to draw the teeth together in a locking action.

If the teeth cannot be drawn together, it will be necessary to remove the slide. This necessitates cutting the stitching at the bottom of the tape and removing the zipper stop which is clamped to the tape rim. Then, starting at the bottom, the slide is aligned on the tape rims so that it is parallel on both rows of teeth. Then, it is pulled upward, meshing the rows of teeth.

In some cases, it may be necessary to lock the teeth together before installing the slide. In this case, both tracks are held together with thumb and forefinger of one hand. With thumb and forefinger of the other hand, teeth are meshed together, one set at a time, by moving the "holding" hand upward each time to grasp the last set of teeth meshed.

Repairs to zippers are, in most cases, easy, but they are time-consuming and require patience. With a reasonable amount of care, zippers can be kept in good operating condition.

6 40

TITANIUM

Onset-of-Creep Stress Measurements

A New Technique, and the equipment for using it, are being developed at GD/Convair under a NASA contract for testing and predicting creep of materials to be used on a Mach 3 transport.

The technique must be developed because current methods are inadequate. Creep is the plastic deformation under stress of a heated material over a period of time, that would not occur if stresses were applied only briefly. GD/Convair, as well as other companies and agencies, has been investigating creep for some years, particularly with respect to the high-temperature-resistant metals sure to be used in supersonic flight—titanium, nickel alloys, and stainless steels. Data, formerly accumulated, are all based on relatively short-time tests lasting 150 to 1000 hours. The supersonic transport is expected to last 30,000 to 50,000 hours; for such a life, creep predictions can be based only on extrapolation of present data, a hazardous procedure.

Creep depends on stress, temperature, and time. Supersonic skin temperatures—up to 650°F at Mach 3.2—are uncomfortably close to the point at which most metals will creep under stress loadings associated with flight. There are no data on creep over a period of 30,000 hours, and no five to ten years time to accumulate such data by empirical experimentation.

The GD/Convair approach is based on observations suggesting that, at a specific temperature, there is a stress intensity at which a creep threshold exists. Creep curves display a characteristic drop and leveling off as applied stresses diminish. Below this "onset-of-creep" threshold, creep is negligible almost to the point of not existing. If families of curves can be worked out for onset of creep under the standard variations of temperature, stress, and time, creep onset can be predicted by interpolation between known data points, rather than by extrapolation beyond known data.

The importance of determining this point of onset of creep lies in a basic requirement of current structural design practice. In the past, structural analysis of complex structures has never been a rigorously exact technique; it has always required verification by test of carefully chosen structural elements. This will be just as true for building a supersonic transport. Ribs, spars, control surfaces, and, finally, complete wings and fuselages will be tested, most of them to destruction.

But creep has never been a design factor. Should it have to become a design factor—that is, should designers have to take into account continuous deformation during the life of a structure—there could be no assurance of sound design without actual test of chosen elements through a period equal to the anticipated life; only a 30,000-to-50,000 hour test could verify such a design—and that figures out to nearly six years.

The onset-of-creep concept envisions design at stresses where creep is not a factor. This can be possible only if a designer can know with certainty that a certain material, at a certain anticipated temperature, will not creep until the stress load increases beyond a certain point. GD/Convair hopes to be able to lead the way toward establishing such design criteria.

Besides a new approach, new apparatus is necessary. In previous investigations, emphasis was to determine amount of creep under circumstances when it was known creep would occur. In determining "onset," the increment to be measured is much smaller —a hundred-millionth to a ten-millionth inch per hour. Precise control of temperature of test materials must be maintained.

The test equipment is, at this writing, in the assembly and calibration stage. The first tests will probably be run in the range of present primary interest, from 400° to 700°F. Material will include three titanium alloys including Ti 8A1-1Mo-1V, and four stainless and one Maraging steel.

GENERAL DYNAMICS | CONVAIR